of the El Niño-Southern Oscillation. This same technique has also shown linkages between transport of air pollution across the North Atlantic and a particular phase of the North Atlantic Oscillation. The consequence of such transport is that it may impact regions downwind and their ability to meet their ozone attainment goals. In addition, we have recently developed an approach to provide 48-hour air quality forecasts of PM 2.5 across the United States utilizing satellite-derived aerosol products from the MODIS (Moderate Resolution Imaging Spectrometer) instrument and meteorological data from the ETA model. Relationships between the movement of high PM events and prevailing meteorology are presented. Both of these state-of-the-art approaches highlight how satellite observations uniquely identify the regional aspect of air pollution, and how such information can be used to study linkages between pollution and climate, and even provide the foundation for air quality forecasts.

U31D-06 1200h

Dust, Climate, and Human Health

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Air pollution from both natural and anthropogenic causes is considered to be one of the most serious worldwide environment-related health problems, and is expected to become worse with changes in the global climate. Dust storms from the atmospheric transport of desert soil dust that has been lifted and carried by the winds - often over significant distances - have become an increasingly important emerging air quality issue for many populations. Recent studies have shown that the dust storms can cause significant health impacts from the dust itself as well as the accompanying pollutants, pesticides, metals, salt, plant debris, and other inorganic and organic materials, including viable microorganisms (bacteria, viruses and fungi). For example, thousands of tons of Asian desert sediments, some containing pesticides and herbicides from farming regions, are commonly transported into the Arctic during dust storm events. These chemicals have been identified in animal and human tissues among Arctic indigenous populations. Millions of tons of airborne desert dust are being tracked by satellite imagery, which clearly shows the magnitude as well as the temporal and spatial variability of dust storms across the "dust belt" regions of North Africa, the Middle East, and China. This paper summarizes the most recent findings on the effects of airborne desert dust on human health as well as potential climate influences on dust and health

U32A MCC: Level 1 Wednesday 1330h

Health, Air Pollution, and Climate III Posters

Presiding: **T Holloway,** Gaylord Nelson Institute for Environmental Studies, University of Wisconsin-Madison**; G McKinley,** Princeton University

U32A-0025 1330h POSTER

Partitioning the Effects of Weather and Air Pollution on Human Mortality in Santiago, Chile: 1988-1996

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The "synergistic" or "interactive" nature of the combined impacts of weather and air pollution on human health has been the topic of much speculation, but few epidemiological studies have measured whether their combined effects are antagonistic, additive, or non-linear. The present study uses a synoptic climatological approach to identify regional weather patterns associated with poor air quality and elevated mortality in the Central Valley of Chile during the winters of 1988-1996. Two offensive weather classes were identified: extratropical low pressure systems and days with cold, dry, high pressure conditions. The offensive pollution classes had mild weather conditions best described as a surface coastal low. Offensive weather and offensive pollution conditions were both associated with a 4% increase in the risk of mortality. Surprisingly nitrogen oxide (NO) was more consistently associated with elevated mortality than fine or coarse fraction particulates. On days in which offensive weather and offensive pollution conditions coincided, the risk of mortality increased 10%, suggesting that during the winter in Santiago, the effects of weather and pollution on mortality are additive and independent.

U32A-0026 1330h POSTER

Aerosol Optical Thickness Variability in the New York Metropolitan Area

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In July 2003 this field study was performed as part of the NASA Goddard Institute for Space Studies Summer Program "Institute for Climate and Planets". The spatial variability of aerosol spectral optical thickness (AOT) in the New York Metropolitan area was measured with a hand held sun photometer "Microtops II". Measurements were taken on board of a cruise ship around Manhattan, and several transects from North to South and East to West within New York City including on top of the Empire State Building. These data are compared to other available ground observations of urban aerosols and to satellite data from MODIS. Consequences of the spatial variability of the effect of urban aerosols on climate will be discussed.

U32A-0027 1330h POSTER

Climate Change and Ozone Air Quality Over the Eastern United States: A Modeling Study

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This paper describes results of a modeling study aimed at simulating the effects of global climate change on climate and air quality over the northeastern United States with a focus on the New York City metropolitan area. The modeling system used for this study consists of the Goddard Institute for Space Studies (GISS) Global Atmosphere-Ocean Model; the PennState/NCAR MM5 mesoscale meteorological model; the Sparse Matrix Operator Kernel Emissions Modeling System (SMOKE); and the Community Multiscale Air Quality (CMAQ) model for simulating air quality. Simulations were performed for five summer seasons each during the 1990s and future decades. An evaluation of the present-day climate and air quality predictions indicates that the modeling system largely captures the observed climate-ozone system. This is established through map-typing analyses, comparison of observed and predicted distributions of meteorological variables and ozone, as well as a comparison of observed and predicted extreme heat and pollution events. Analysis of future-year predictions shows an increase in temperature and humidity as well as mean and extreme ozone concentrations under the IPCC A2 emission scenario. In addition to the analysis of mean summertime temperature, precipitation, mixing height, and pollutant concentrations, an analysis of the changes in the severity and duration of extreme heat and pollution events is presented. Furthermore, through a series of sensitivity studies the question is addressed whether changes in meteorology due to global climate change or changes in emissions have the largest impact on predicted ozone concentrations. The modeling results are also discussed in terms of their application to the analysis of public health impacts of changing climate and air quality in the New York City region.

U32A-0028 1330h POSTER

Assessing Public Health Impacts of Heat and Air Quality Under a Changing Climate in the New York City Metropolitan Area

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New tools are needed for assessing public health impacts of climate change. This paper describes the results of an integrated assessment of the health impacts of global climate change in the New York metropolitan region, projected for the decade of the 2050s. The model systems used for this study are the Goddard Institute for Space Studies (GISS) Global Atmosphere-Ocean Model; the Penn State/NCAR MM5 mesoscale meteorological model; the Sparse Matrix Operator Kernel Emissions Modeling System (SMOKE); and the Community Multiscale Air Quality (CMAQ) model for simulating air quality. Simulations are performed for five summer seasons each during the 1990s and the 2050s, using greenhouse gas emissions projections from the Intergovernmental Panel on Climate Change (IPCC) A2 scenario. The GISS global climate model at 4 x 5 degree horizontal resolution is used as input to the MM5 model run at nested grids down to 36 km resolution. The MM5 at 36 km subsequently serves as input for the CMAQ ozone simulations. A risk assessment modeling framework is used to estimate summer heat- and ozone-related mortality in the region, with a focus on comparing respective estimates for the 1990s versus the 2050s. These endpoints represent two potentially appreciable public health impacts resulting from climate change-induced alterations in regional temperature and air quality profiles. Concentration-response functions from the epidemiological literature describing temperature-mortality and ozone-mortality relationships are applied in the risk assessment, to estimate numbers of regional deaths in a typical 1990s summer and a typical 2050s summer. An evaluation to define ozone-related mortality uses a minimum-value threshold applied across the 1-hour daily maximum ozone model outputs, to identify days that pose an elevated relative risk of ozone mortality. A parallel evaluation of heat-related mortality applies a 23.08°C (73.54°F) threshold value, above which the relative risk of heat-related mortality increases by 13.05% per 5.6°C (10°F). Preliminary analysis of future-year ozone-related mortality suggests a subtle increase in the number of summer ozone-related deaths in the New York region in the 2050s as compared to the 1990s. A parallel evaluation of heat-related mortality in a typical summer of the 2050s suggests a far greater relative increase as compared to the 1990s, with a doubling to tripling of regional summer heat deaths possible by the 2050s.

U32A-0029 1330h POSTER

Large Scale Numerical Modelling to Study the Dispersion of Persistent Toxic Substances Over Europe

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For the past two decades environmental research at the GKSS Research Centre has been concerned with airborne pollutants with adverse effects on human health. The research was mainly focused on investigating the

dispersion and deposition of heavy metals like lead and mercury over Europe by means of numerical modelling frameworks. Lead, in particular, served as a model substance to study the relationship between emissions and human exposition. The major source of airborne lead in Germany was fuel combustion until the 1980ies when its use as gasoline additive declined due to political decisions. Since then, the concentration of lead in ambient air and the deposition rates decreased in the same way as the consumption of leaded fuel. These observations could further be related to the decrease of lead concentrations in human blood measured during medical studies in several German cities. Based on the experience with models for heavy metal transport and deposition we have now started to turn our research focus to organic substances, e.g. PAHs. PAHs have been recognized as significant air borne carcinogens for several decades. However, it is not yet possible to precisely quantify the risk of human exposure to those compounds. Physical and chemical data, known from literature, describing the partitioning of the compounds between particle and gas phase and their degradation in the gas phase are implemented in a tropospheric chemistry module. In this way, the fate of PAHs in the atmosphere due to different particle type and size and different meteorological conditions is tested before carrying out large-scale and long-time studies. First model runs have been carried out for Benzo(a)Pyrene as one of the principal carcinogenic PAHs. Up to now, nearly nothing is known about degradation reactions of particle bound BaP. Thus, they could not be taken into account in the model so far. On the other hand, the proportion of BaP in the gas phase has to be considered at higher ambient temperatures. The gaseous BaP is known to be subject to various degradation and metabolisation reactions caused by oxidants and sunlight. The model will be used to assess human exposure to various PAHs and their metabolites depending on different emission and weather scenarios either directly via PAHs in ambient air or by accumulation in the food chain when they are deposited over agricultural or fishing areas.

U32A-0030 1330h POSTER

One Hundred Years of New York City's "Urban Heat Island": Temperature Trends and Public Health Impacts

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In this paper, we examine the relationship between the historical development of New York City and its effect on the urban climate. Urban "heat islands" (UHI) are created principally by man-made surfaces, including concrete, dark roofs, asphalt lots and roads, which absorb most of the sunlight falling on them and reradiate that energy as heat. Many urban streets have fewer trees and other vegetation to shade buildings, block solar radiation and cool the air by evapotranspiration. The historical development of the NYC heat island effect was assessed in terms of average temperature differences of the city center relative to its surrounding 31-county metropolitan region, comprised of parts of New York State, New Jersey, and Connecticut. Monthly maximum and minimum temperatures for 1900-1997 were obtained from NOAA's National Climatic Data Center, the NASA-Goddard Institute for Space Studies, and the Lamont-Doherty Earth Observatory of Columbia University for 24 weather stations within the region that are part of the U.S. Historical Climatology Network. Analysis of annual mean temperatures shows an increasing difference between NYC (Central Park weather station) and its surrounding region over the twentieth century. Analysis of the temperature differences over time between NY Central Park (NYCP) station and 23 regional weather stations classified according to distance and level of urbanization show a heat island effect existing in NYC, with mean temperatures in the NYCP Station generally higher than the surrounding stations, ranging from 1.20°C to 3.02°C. A difference of at least 1°C already existed at the beginning of the 20th century between the mean temperature in NYC and its surrounding rural areas, and this difference increased over the twentieth century. There was a significant decrease in the monthly and seasonal variability of the UHI effect over the century. Temperature extremes and summertime heat can create heat stress and other health consequences for urban residents. Public health impacts are assessed as the proportion of heat-related regional mortality estimated to be attributable to New York City's heat island effect during an average 1990's summer. Concentration-response functions describing the temperature-mortality relationship in NYC derived from the epidemiological literature are used to estimate numbers of deaths in a typical 1990s summer and those attributable to the city's heat island effect. The techniques and potential public health benefits of a pilot project to mitigate the heat island effect in NYC will be discussed.

U32A-0031 1330h POSTER

Evaluating the Impact of Air Pollution on Human Health in China: the Price of Clean Air

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Population growth, rapid urbanization and economic development are contributing to increased energy consumption in China. One of the unintended consequences is poor air quality due to a lack of environmental controls. The coal dependent energy structure in China only worsens the situation. Quantification of the environmental costs resulting from air pollution is needed in order to provide a mechanism for making strategic energy policy that accounts for the life-cycle cost of energy use. However, few such studies have been conducted for China that examine the entire energy system. Here we examine the extent to which public health has been compromised due to elevated air pollution and how China could incorporate environmental costs into future energy and environmental policies. Taking the Shandong region in eastern China as a case study, we develop a high-resolution regional inventory for anthropogenic emissions of NOx, CO, PM2.5, PM10, VOCs, NH3 and SO2. SMOKE (Sparse Matrix Operator Kernel Emissions Modeling System) is used to process spatial and temporal distributions and chemical speciation of the regional emissions, MM5 (the Fifth-Generation NCAR/Penn State Meso-scale Model, Version 3) is used to generate meteorology and Models3/CMAQ (Community Multi-scale Air Quality Modeling System) is used to simulate ambient concentrations of particulates and other gaseous species in this region. We then estimate the mortality and morbidity in this region resulting from exposure to these air pollutants. We also estimate the monetary values associated with the resulting mortality and morbidity and quantify the contributions from various economic sectors (i.e. power generation, transportation, industry, residential and others). Finally, we examine the potential health benefits that adoption of best available or advanced energy (coal-based, in particular) and environmental technologies in different sectors could bring about. The results of these analyses are intended to provide insight into whether China should choose to continue business as usual, adopt marginal, additional environmental controls for conventional energy technologies, or leapfrog to advanced, low-emission energy technologies. Finally, we make recommendations on which energy sector priority should be placed after environmental costs are taken into account.

U32A-0032 1330h POSTER

Roadside Accumulation of Pt, Pd, Rh and Other Trace Elements From Automobiles: Catalytic Converter Attrition and Platinum-Group Element Mobility in the Roadside Environment.

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Elemental abundances of Pt, Pd and Rh have been documented across the industrialized world in roadside environments due to attrition of automotive catalytic converters (Zereini and Alt, 2000, Anthropogenic PGE Emissions, Springer, 308pp; Ely et al., 2001, EnvSci&Tech, 35:3816-3822; Whiteley and Murray, 2003, SciTotEnv, in press). In our ongoing study, the highest reported roadside Pt abundance 1.8 ppm has been found immediately adjacent to the road at a field site in South Bend, IN, USA. Furthermore, initial studies show positive correlations of Pt, Pd and Rh with some trace elements (Ni, Cu, Zn and Pb), which has been confirmed by further analysis for these and other elements (Ce, Cr). It has been demonstrated that elements such as Ce are present in catalytic converters at concentrations of 100's ppm to 3-wt.%. These elements are also being attrited with Pt, Pd and Rh and aerially transported and deposited. Our field site was established next to US-933 adjacent to the Notre Dame campus. Areas were cleared of the top 2-4 cm of soil (removing surficial Pt, Pd and Rh) at 1, 5, 10 and 50 meters from the roadside. Within 3 months the 1-meter site contained 67% of the initial Rh and Pt concentrations and 100% of the initial Pd concentration. The sites at 5, 10 and 50 meters showed similar results, in some cases exceeding the initial concentrations. After 6 months the concentrations of Pt, Pd and Rh were all within error of the initial concentrations, indicating steady state abundances had probably been reached. Grass samples from each site showed that washed vs. unwashed samples were within error of each other, and there may be a slight enrichment (approx. 1 ppb) in the grasses of Pd and Pt, but this enrichment was independent of distance from the road. The steady-state situation suggests that the PGEs are being removed from the immediate roadside environment, which requires that the metals are being oxidized and/or complexed in such a way to facilitate transport. The environmental effects of such processes are unknown, but Pt complexes are known carcinogens. Electron microprobe and SEM analysis are being used to isolate particles using these surrogate trace elements in an ongoing effort to determine the oxidation state (using XANES) of Pt, Pd and Rh in the natural environment.

U32A-0033 1330h POSTER

A Healthy Reduction in Oil Dependence and Carbon Emissions

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Societal dependence on oil as an energy source for personal transportation leads to increasingly negative social consequences including climate change, air pollution, political and economic instability and habitat degradation. Our heavy reliance on the automobile for transportation, determined in part by urban sprawl, also contributes to the population's increasingly sedentary lifestyle and to a concomitant degradation in health. We have shown that widespread substitution of exercise, commensurate with previously recommended levels, through biking or walking instead of driving can substantially reduce oil consumption and carbon emissions. For example, if all individuals between the ages of 10 and 64 substituted one hour of cycling for driving the reduction in gasoline demand would be equivalent to the gas produced from 34.9 percent of current oil consumption. Relative to 1990 net US emissions, this constitutes a 10.9 percent reduction in carbon emissions. Therefore, substitution of exercise for driving could improve health, reduce carbon emissions and save more oil than even upper estimates of that contained in the Arctic National Wildlife Refuge.

U32A-0034 1330h POSTER

Environmental and Health Benefits and Risks of a Global Hydrogen Economy

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Rapid development in hydrogen fuel-cell technologies will create a strong impetus for a massive hydrogen supply and distribution infrastructure in the coming decades. Hydrogen provides an efficient energy carrier that promises to enhance urban and regional air quality that will benefit human health. It could also reduce risks of climate change if large-scale hydrogen production by renewable or nuclear energy sources becomes

viable. While it is well known that the byproduct of energy produced from hydrogen is water vapor, it is not well known that the storage and transfer of hydrogen is inevitably accompanied by measurable leakage of hydrogen. Unintended consequences of hydrogen leakage include reduction in global oxidative capacity, changes in tropospheric ozone, and increase in stratospheric water that would exacerbate halogen induced ozone losses as well as impact the earth's radiation budget and climate. Stratospheric ozone depletion would increase exposure to harmful ultraviolet radiation and increased risk to melanoma. We construct plausible global hydrogen energy use and leak scenarios and assess their impacts using global 3-D simulations by the Model for Ozone And Related Trace species (MOZART). The hydrogen fluxes and photochemistry in our model successfully reproduce the contemporary hydrogen cycle as observed by a network of remote global stations. Our intent is to determine environmentally tolerable leak rates and also facilitate a gradual phasing in of a hydrogen economy over the next several decades as the elimination of the use of halocarbons gradually reduces halogen induced stratospheric ozone loss rates. We stress that the future evolution of microbial soil sink of hydrogen that determines its current lifetime (about 2 years) is the principal source of uncertainty in our assessment. We propose global monitoring of hydrogen and its deuterium content to define a baseline and track its budget to responsibly prepare for a global hydrogen economy.

U32A-0035 1330h POSTER

The Dynamics and Characteristics of Aeolian Dust in Dryland Central Asia: Possible Impacts on Respiratory Health in the Aral Sea Basin

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Over the last 40 years over 36,000 km2 of the former Aral Sea bed have been exposed creating a potentially significant aeolian dust source. It is widely believed, but little researched, that increased dust storm activity in the region has had a major impact on human health. In this paper we report the findings of a study into the link between dust exposure and respiratory health amongst children in the Autonomous Republic of Karakalpakstan, located on the southern shore of the Aral Sea.

Data were collected over a 12 month period at 16 sites located within a broad transect running north to south through Karakalpakstan. At each site monthly measurements of dust deposition were undertaken linked with daily meteorological data at 6 stations. At 3 sites weekly measurements of PM10 were also carried out. Approximately 100 children (aged 7-10 years) were randomly selected within 5 km of each dust trap site and data were collected on their respiratory health and environmental exposures. Lung function data were also collected using a handheld spirometer. A linear regression model was used to predict lung function for the children incorporating variables for Forced Expiratory Volume in one second (FEV1), age, gender, height and weight and we estimated the impact of dust deposition rates on the odds of having abnormal lung function using logistic regression.

The findings indicate that dust deposition rates across the region are high with sites located near the former shore of the sea being the worst affected. For these northerly regions the former Aral Sea bed is the most likely source of dust. The situation for the rest of the country seems to be far more complex. In these regions it appears that local sources (agricultural fields, abandoned irrigation grounds, overgrazed dunes, and unpaved roads) and more distant sources to the south and south-west represent significant sediment providers, particularly in the early summer when agricultural fields are ploughed. We found some evidence of a dose-related impact of dust levels on lung function. These associations were statistically significant for all measures of dust exposure but were most marked for levels of winter dust exposure and level of PM2.5 exposure.

The results from this study suggest that aeolian dust dynamics in the region are spatially and temporally highly variable and, counter to local and regional perceptions, the former bed of the Aral Sea does not appear to be the only significant source. Nevertheless, there is also evidence of a dose-related impact of airborne dust on the risk of having abnormally low lung function in children living in the Aral Sea Area.

U32B MCC: 3016 Wednesday 1340h

Recent Infrasound Studies, Phenomena, and Development II

Presiding: **C Hayward,** Southern Methodist University**; M A Hedlin,** Laboratory for Atmospheric Acoustics, Institute of Geophysics and Planetary Physics, University of California, San Diego

U32B-01 1340h INVITED

Charting a Course for the Infrasound Renaissance

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The turn of the 21st century marks the onset of a renaissance in the field of infrasound, which had been dormant for 30 years. The ongoing deployment of a global infrasound network has reawakened the field to a world of high-resolution digital array data, rapid communication, and seemingly unlimited growth in computing power. Complex phenomena that could only be addressed in general terms three decades ago can now be measured, analyzed, and modeled with unprecedented fidelity. Many fundamental problems in infrasound are now being revisited, and infrasonic observations are being integrated with other technologies (such as seismic, strainmeter and infrared) for the discovery of new phenomena or the refinement of geophysical studies. On July 24-25, 2003, the National Science Foundation sponsored a group of infrasound experts and interdisciplinary researchers to convene in Waikoloa, Hawaii, and chart a course for basic US infrasound research. The conveners selected key projects that would lead to significant advances in our understanding of infrasound generated by effusive and explosive volcanoes, ocean swells, bolides, fauna, severe weather, and long-period atmospheric instabilities. Projects were also proposed to refine our knowledge of atmospheric dynamics and transport mechanisms. A sampling of these projects is discussed in light of their contributions to our fundamental scientific understanding and their impact on the geophysical community.

URL: http://www.inframatics.org

U32B-02 1400h INVITED

Report to the Department of Defense on Infrasonic Re-entry Signals From the Space Shuttle Columbia (STS-107) (Revision 3.0)

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Infrasound signals recorded by ten stations during the reentry of Shuttle STS-107, are analyzed in an attempt to better understand the cause of this tragedy. These prototype infrasound stations recorded clear signals from this shuttle as well as from several previous missions. As sound passes through the atmosphere, stratification of winds and temperature as well as turbulence modifies the received signal. Sound propagating from source to receiver along different paths can arrive at the receiver at different times giving rise to bursts of signal. A single impulsive event such as a shock wave or an explosion might give rise to several clear receptions. Consequently, it is difficult to separate nearby events from atmospheric multi-path effects. Below and to each side of the shuttle path, there is a sonic boom carpet. Receivers within this carpet recorded the Shuttle's sonic boom, while outside the carpet, signals similar to those from subsonic sources were observed. These infrasound arrays can determine the direction of the signal. When combining these data with the trajectory of the shuttle, we find the primary signal is located from near the direction of the shuttle's closest approach (or slightly West of that location) to within the few tens of km accuracy usually associated with infrasound localizations. This means that there do not appear to be other sources of infrasound in the vicinity of the shuttle. All stations observed multiple arrivals associated with sound generated during the approach of the shuttle. These arrivals may be explained by multiple paths through the atmosphere but it is possible that some come from fragments or debris. The U. S. infrasound community has not examined in detail shuttle reentry signals in the past so it is difficult to identify anomalies in the signal. Our analysis team compared signals recorded for STS-107 to flights STS-77, STS-78, and STS-90 which had similar re-entry trajectories but fewer infrasound stations on line. The sonic boom waveforms from each mission were different in detail but essentially the same in major features. Noticeable differences in the STS-107 signals were an especially long (almost an hour) acoustic signal following the sonic boom coming from the West. There was a less clear indication of a change in the recorded waveform over the CA-NV border region. There is insufficient data from previous missions to determine if such a change is expected.