STATEMENT FOR OCEANOGRAPHY (as seen from the French side….)

The Science Questions

a) **What is the variability in eddy currents and the resulting impact on global climate and weather?**

We agree that this point is a top priority for the missions. The role of the internal ocean adjustment to changes in the surface climate forcing has been revealed by the evolving EKE field at seasonal, interannual and decadal time-scales. Although our 15-years of traditional nadir altimetric observations have greatly improved our understanding of these variations, we are missing an important part of the EKE spectrum from 30-100 km wavelength, and from 3-20 days. This missing part of the EKE spectrum is important in the tropics where the adjustment timescales are fast, and where we are presently missing much of the tropical instability wave energy with traditional altimetry observations. This part of the EKE spectrum is particularly important in the mid-to-high latitude bands where the Rossby radius decreases, and the adjustment time-scales are reduced as the barotropic response becomes more important. The mid-to-high latitude band is where the most intense currents and internal adjustment occurs, but is also the seat of mode, intermediate and deep water formation. The formation of these subsurface water masses is linked to mesoscale ocean processes at the Rossby radius, and any modification of the eddy exchange processes here will impact directly on the global thermohaline circulation.

Our early studies suggest that WATER-HM observations at 4 days and at 24-30 km will greatly improve our understanding of the internal ocean adjustment at mid latitudes. Studies are on-going to estimate the high-latitude requirements.

b) **What are the effects of coastal circulation on marine life, ecosystems, waste disposal, and transportation.**

Progress towards this second goal is timely and critical because of its societal implications, and because the contribution of WATER-HM to the observation of the (presently poorly measured) coastal domain would be major both qualitatively and quantitatively. We would add to the science question the issues of water quality (linked to tourist activities and waste management), disaster prevention (storm surges, oil spills), and sediment transport and coastal erosion. Although these applications are beyond the scope of the mission, we believe that WATER-HM will provide solid scientific foundations towards these objectives.

We are starting to get a good idea of the coastal model errors we must aim at correcting with the help of satellite altimetry. Exploration of the error subspace of hydrodynamical coastal models is underway using advanced techniques (ensemble or adjoint-based methods). It appears from these approaches that ideally, coastal science studies would require O(1day) resolution at O(200km) horizontal scales (gravity waves, shelf response to the atmosphere) and O(4day) resolution at O(20km) scales (coastal mesoscale, upwellings, filaments, fronts). This cannot be achieved with a single wide-swath mission. Quantitative impact studies have been performed with the above techniques. They objectively demonstrate that a single wide-swath instrument on a JASON-type orbit would significantly constrain the coastal ocean
mesoscale and coastal current variability. They also suggest that yaw errors might be more difficult to separate from coastal processes than roll errors because of their shorter along-track scales. Also, swath overlap is a desired feature in the coastal domain to maximize revisit time and better constrain the higher-frequency part of the spectrum of coastal processes.

c) How can hurricane lead-time forecasts be improved?
We think this is an important issue, but can also be extended to a more general case of better understanding the ocean response and air-sea interaction under storm conditions, and for example coastal storm surge prediction from intense storms.

We would also like to see this question to be added to the science question list: 
*What is the impact of internal wave generation/propagation/dissipation (or transformation) on the ocean mixing, and consequently on the ocean circulations?*

The generation of the internal tides is the second major dissipation process for the barotropic tides (25 to 30%). Part of the internal tides are rapidly trapped by the local topography, part of them can propagate over very long distances. The fate of the internal tide energy is not so clear today. It is thought that it contributes to the ocean mixing in a wave breaking process and/or through ocean bottom increased turbulence. Ocean model simulations addressing the thermohaline circulation have demonstrated that such a mechanism, if accounted for in the model parameterisations, does improve the global over-turning estimates in the model. The impact of long-range propagating internal waves is probably also significant for the ocean upper stratification. Clearly, those waves, generated at mid-latitudes, disappear when they reach the equatorial band in the Pacific Ocean. The dissipation, or transformation of those waves when reaching this region, need to be understood and quantified. A global mapping of the surface signature of the internal tides would give access to an unprecedented and highly valuable knowledge of their dynamics and energy budget, and the mean to relate further their generation/propagation/destruction cycle to the ocean mixing at all depths. To my opinion, the high/low frequencies coupling is one of the major ocean science challenge, and internal tides are part of this challenge.
Mesoscale and sub-mesoscale eddy velocities from the WATER HM mission

Scientific Rationale
Rosemary Morrow, LEGOS, Toulouse

The following is in addition to the scientific rationale presented in the first document of the WATER Satellite mission.

The present 15-year long time series of gridded altimeter data from 2-4 nadir-looking radar altimeters has allowed us to consider the seasonal and interannual variations in eddy kinetic energy (EKE), and the dynamics responsible for these changes. Different studies have shown how seasonal EKE variations at mid to high latitudes are linked to seasonal wind stress variations (Brachet et al., 2004; Qiu, 1999; Qiu and Chen, 2004), although other forcing mechanisms may also be important (Eden and Boning, 2002). Penduff et al., (2004) found that strong climate mode forcing from NAO events after 1994 were followed by gyre-scale EKE fluctuations with a 4–12-month lag, suggesting complex and nonlinear adjustment processes. In the Southern Ocean, Morrow et al. (2004) have shown how interannual variations in EKE can be linked to interannual changes in the position and strength of the Subantarctic Front, and Sallée et al (2007) have highlighted a net increase in EKE by 10% in the energetic currents, in phase with the net sea level rise in the Southern Ocean during 1993-2003.

These observational studies reveal the important link between the surface forcing changes and the internal ocean adjustment. The traditional nadir-looking altimeter observations can provide us with eddy kinetic energy estimates from the large instabilities (> 75-100 km wavelength, and > 20 days). However, important EKE changes may also occur at wavelengths of 30-100 km, and 3-20 days, which we are missing with our present altimetric sampling.

Previous studies have compared the mapping capabilities of 2-4 traditional nadir altimetry missions with a high-resolution ocean circulation model (Los Alamos 1/10° OGCM) (Ducet, 2000; Le Traon and Dibarboure, 2002). Although sea level can be mapped with an accuracy of 5-10% of the signal variance, these studies show that the velocity field has a much larger mapping error (20-40% of the signal variance). This error has a direct impact on the estimation of eddy kinetic energy or relative vorticity of the flow, and the rate of exchange between the mean currents and the turbulent eddy field. A large part of the mapping error is due to high frequency (< 20 days) and high wavenumber (< 100 km) signals. The high frequency part of the spectrum is particularly important in the tropical latitudes, in the coastal zone, and at high latitudes. The high wavenumber signals are especially important at mid to high latitudes, where the most intense current systems are located (western boundary currents, Antarctic Circumpolar Current). These latitude bands are also where most of the world’s intermediate and deep waters are generated or modified. The formation processes for these water masses which form the global thermohaline circulation, occurs on the scales of a few tens of kilometres. Thus the exchange window between any climate modification at the ocean surface, and its impact on the global thermohaline circulation, is largely controlled by these eddy-scale processes at mid-to-high latitude, which are not adequately sampled by our present observations.

A recent intensive research campaign in the NE Atlantic called POMME aimed to identify the role of mesoscale eddy processes in the subduction of mode water and in the development of intense spring blooms (JGR Special Issue, 2005). The project was based on an intense in-situ observational campaign, satellite data, and very high resolution regional ocean circulation
models. Although the project originally targeted the mesoscale eddy processes, it was found that the smaller-scale filaments (10-30 km) entrained around the mesoscale eddies were most important in the advection of tracers (SST, chlorophyll) and in inducing the largest vertical velocities (exceeding 25 m/day) (Paci et al., 2005; Legal et al, 2007). Within the filaments, these large vertical velocities bring nutrient-rich deeper layers into the surface euphotic zone, enhancing the spring blooms. The subduction of mode waters was also strongly determined by these filaments, which induced deeper mixed layers, stronger entrainment across the base of the mixed layer, and formed a denser class of mode waters (Paci et al., 2007).

These finer-scale processes were revealed with a high resolution regional model (1/20° with 69 vertical levels) and very high resolution in-situ data. However, the position of these filaments, and their spatio-temporal evolution, can also be estimated using lagrangian techniques based on horizontal maps of mesoscale eddy geostrophic currents (eg. Abraham and Bowen 2002; D’Ovidio et al, 2007). Thus we can localise these filaments and the associated regions of intense mixing (~10 km width) using altimetry based velocity maps which have a resolution of > 75-100 km. However, as mentioned before, the present generation of gridded velocity maps from traditional nadir altimeter missions are missing the small period and small wavelength features, especially in mid-to-high latitudes. Finer resolution horizontal velocity maps are needed to better resolve these important features. A recent analysis of a 1/54° resolution OGCM from the Japanese Earth Simulator has been used to determine the minimum space-time scales necessary for the horizontal velocity field, in order to accurately position the lagrangian filaments with respect to SST and chlorophyll tracer fields. Preliminary results at mid latitudes suggest that velocity maps at 4 days and 30 km resolution would be required. On-going studies will determine the requirements in other geographical regions.

The wet tropospheric issue for the WATER HM mission

Comments by Estelle Obligis, CLS Space Oceanography, Toulouse

The wet tropospheric correction issue for the WATER HM mission can be separated in two different aspects: 1) how to get a reliable estimation of the wet tropospheric correction into the complete interferometric swath and 2) what can we do to improve the quality of the wet tropospheric correction in coastal and inland waters?

1) In case of the WATER HM interferometric measurement, we can assume that the phase measurement is not impacted by the wet tropospheric correction variability into the swath. Nevertheless the absolute value is needed to deduce the surface height with respect to the nadir reference. The solution of an across-track scanning radiometer would be difficult to implement for the WATER mission, due to the strong constraints on the platform stability imposed by the altimeter processing. High frequency radiometers should be considered instead: antennas are smaller so accommodation on the platform is easier, and above all, measurements are characterized by a much better resolution. Nevertheless, there still remains the problem of the opacity of certain clouds that deteriorates the quality of the retrieved wet tropospheric correction. So this promising solution is probably not mature enough for the WATER HM mission. The most robust approach probably lies on the use of a single optimized reflector associated with several horns to characterize the entire swath. The combination of two channels (K and Ka bands as for the AltiKa mission) is satisfactory in terms of resolution (15 km for a 800 km altitude) and retrieval accuracy. In this case, the altimeter backscattering coefficient is used to get information on surface roughness.

2) Over the open ocean, the combination altimeter/radiometer is satisfactory. This is not the case in coastal zones or inland waters, where the signal coming from the surrounding land surfaces contaminates the radiometer measurement and makes the humidity retrieval method unsuitable. We have developed a radiometer simulator, firstly to perform sensitivity tests and evaluate the performances of the current methods, and secondly to evaluate the feasibility and performances of a new method based on the proportion of land in the “mixed” surface (Desportes et al, 2007). These results are encouraging. This work is continuing with the development of a variational assimilation method. ECMWF temperature and humidity profiles are used as a first guess, and these initial profiles are then adjusted in order to fit simulated brightness temperatures from a radiative transfer model onto the measured ones.