

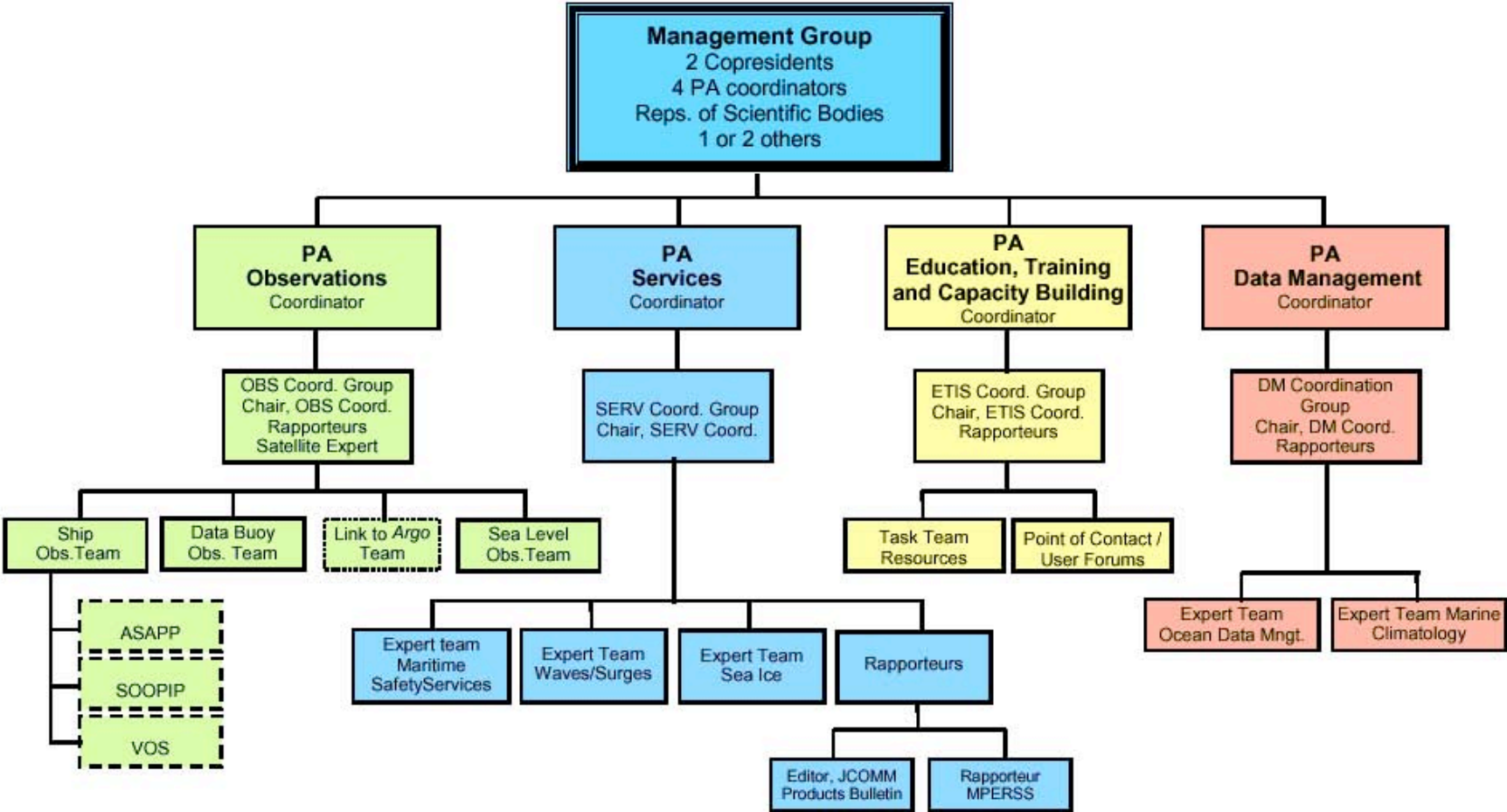
## Annex VIII

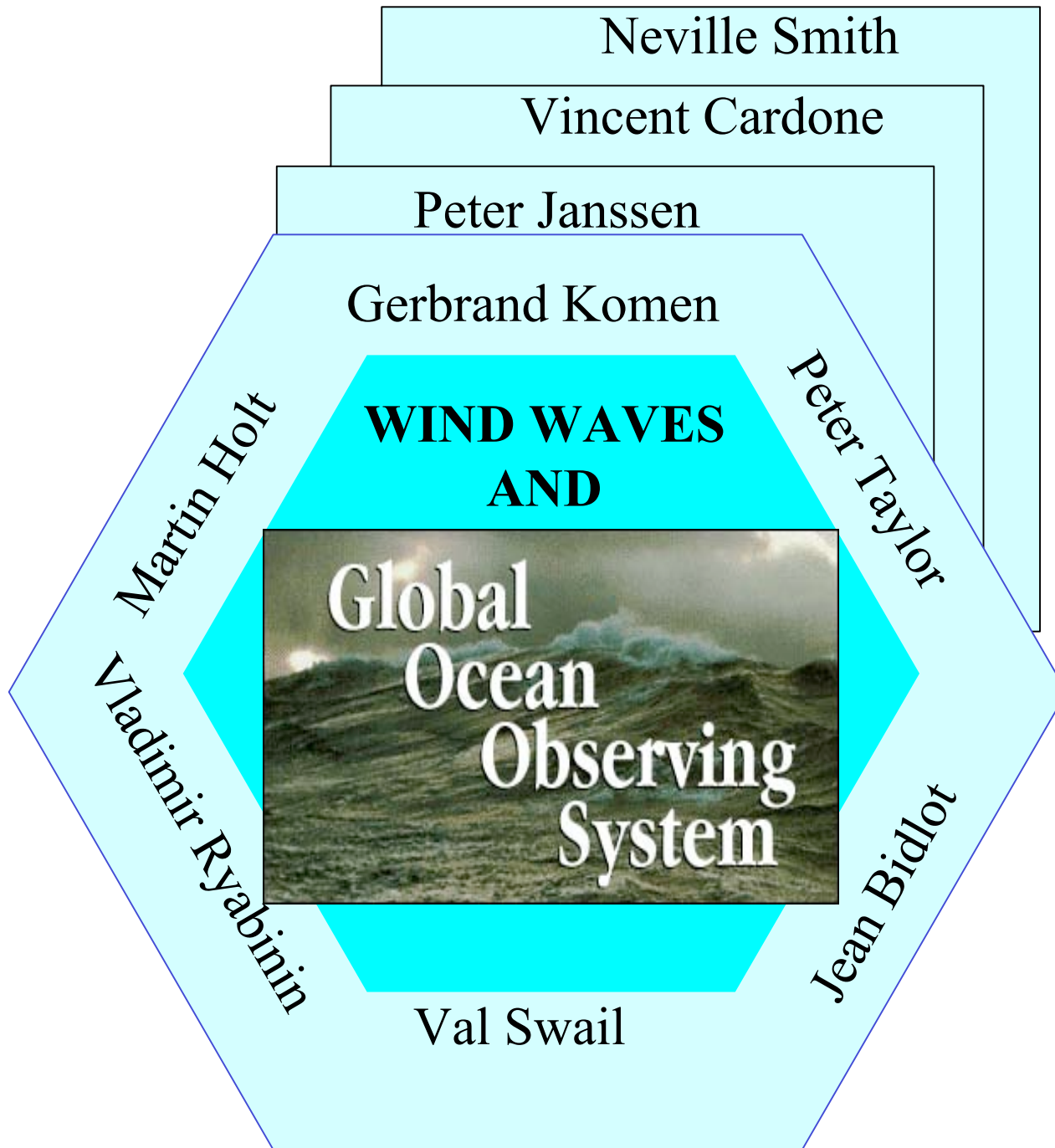
### JCOMM EXPERT TEAM ON WIND WAVES AND STORM SURGES *Terms of Reference*

The Expert Team on Wind Waves and Storm Surges shall:

- Review and advise on the implementation of wind wave and storm surge activities within JCOMM, and as required propose amendments;
- Develop technical advice on wave and storm surge modelling, forecasting and service provision, and as required provide assistance and support to Member States;
- Monitor projects for verification of operational wind wave and storm surge model outputs, and as required assist in their implementation;
- Ensure effective coordination and cooperation with appropriate GOOS bodies on requirements for, and implementation of, wind wave and storm surge products and services;
- Provide advice to the Services Coordination Group and other JCOMM groups, as required, on issues related to wind waves and storm surges.

# PROPOSED JCOMM STRUCTURE



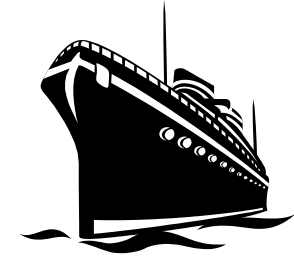


# **METHODS FOR ACQUIRING WAVE INFORMATION**

- VISUAL ESTIMATION**
- DIRECT MEASUREMENT**
- INDIRECT MEASUREMENT - DEDUCTION**
- MODELLING – HINDCAST, FORECAST, REANALYSIS**

Wind Wave Observations

Visual



“+” : longest term data base, sometimes the only observations available, basis for many current climatologies, consistent when used as ensemble but for mean conditions only, mariners’ feedback to services, useful in services such as SaR, useful in development of statistical forecasting techniques, in subjective corrections to wind OA, used in legal cases; ship *wind* observations more useful, but also prone to observational errors.

“-” : subjective, insufficiently accurate for use in data assimilation schemes, considerable scatter of individual observations, hard to automate for VOS, possible fair-weather bias.



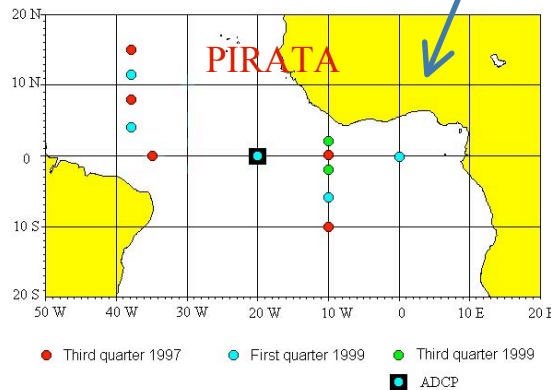
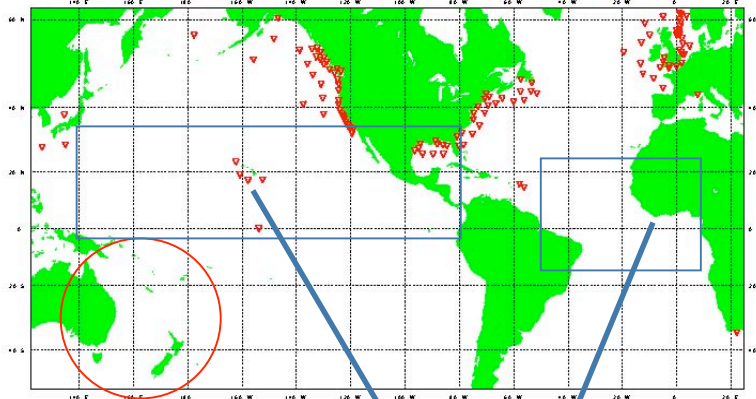
**Automation of Observations (especially wind),  
Message Compilation, Transmission, and Archival**

# Wind Wave Observations

## Instrumented



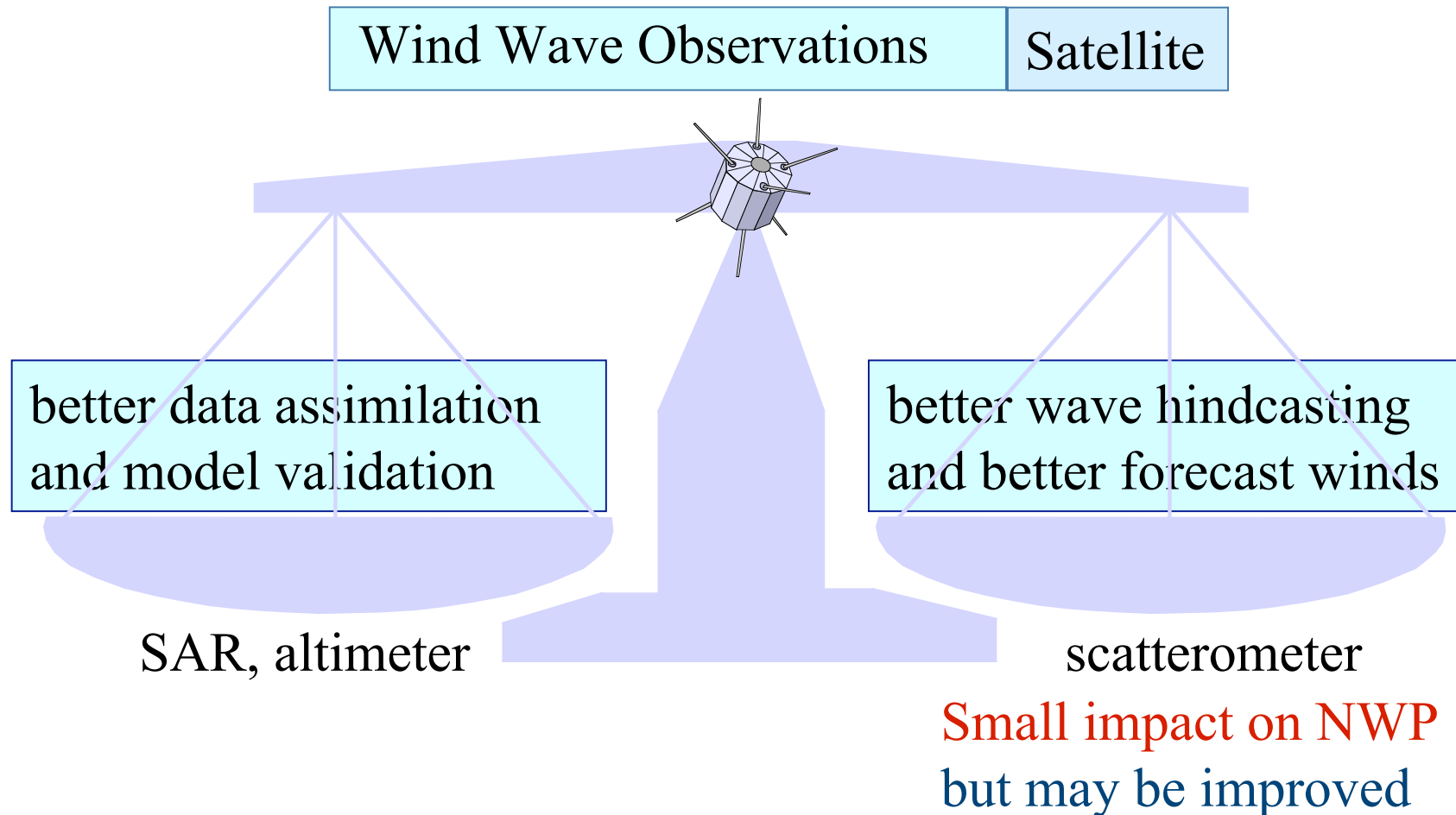
Fixed locations for ocean wave and wind data regularly available on GTS in 1999



“+” : objective, precise, spectral (1-D or 2-D), represent off-shore industry feedback, critical for model verification, and as ground truth for remote sensing, for local climate purposes.

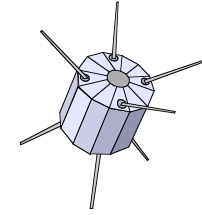
“-” : impact on DaS usually short-lived, insufficient amount of spectral data, particularly directional spectra.

**More spectral, better 2-D, data needed, especially in S. Ocean; encourage the exchange of measured wave data over the GTS; inclusion of in situ wave data on operational moored buoys, need for co-locations of satellite and moored buoy wave heights**



- ✓ maintain at least present coverage of satellite wind and wave data, implementation on “operational” satellites where possible, increased co-ordination of satellite programmes to ensure optimal balance of sensors, mission overlap

## Wind Wave Data Transmission and Archival



Satellites with altimeters are not "operational", and have differing methods for disseminating data. Many of the moored buoy measurements are transmitted in near-real time via the WMO GTS.

Specialised links, the WMO GTS

The main issues:

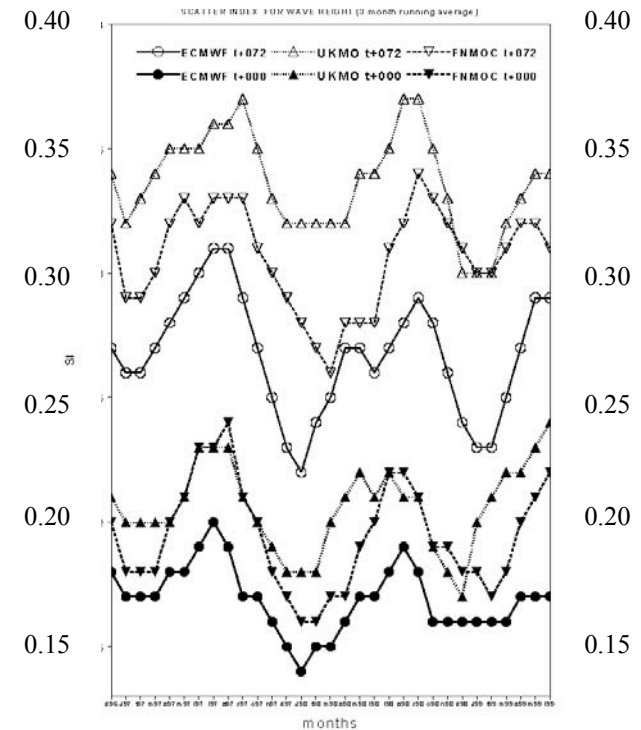
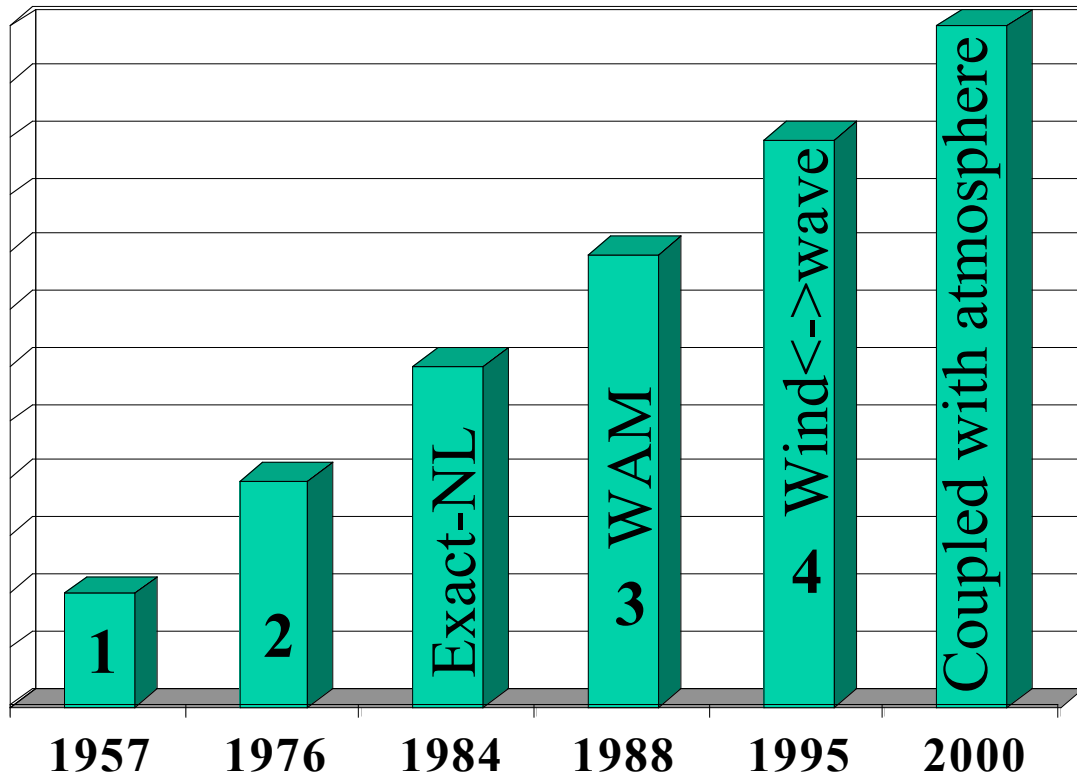
- enforcement of standards for wave data and information transmission,
- facilitation of real-time transmission of the remotely sensed wave data,
- setting up modern standards for instrumented data archiving that would ensure easy data retrieval and its use in multi-disciplinary applications,
- a possible need for a centre (or centres) for the collection and archiving of wave observations and gridded (level III) wave parameter fields,
- a possible need for a project aimed at wave data rescue,
- encouragement for ALL observing centres to distribute real-time data via the WMO GTS.

- ✓ **GOOS must provide a coherent approach to development of marine observing systems on a series of scales. Present coordination of different wind wave observations seems to be insufficient. Fortunately, visual, instrumented, and remote observations mostly serve different purposes.**
- ✓ **A study is required on the development of satellite observations that would result in a balanced proposal on combination of satellite scatterometry, altimetry, and SAR.**
- ✓ **There is a concern that future re-analyses of surface variables and re-constructions of instantaneous fluxes between ocean and atmosphere would be insufficiently accurate for future requirements if proper instrumented observations on surface wave spectrum are not available.**

# SPECIFIC APPLICATIONS

- Wind wave forecasting and related services
- Wave climatology, variability
- Role of wind waves in the coupled atmosphere-ocean system

# Wind Wave Modelling and Numerical Forecasting



Verification project:  
 ECMWF, UKMO,  
 FNMOC, MSC, NCEP

# Wind Wave Data Assimilation

## Pattern of development:

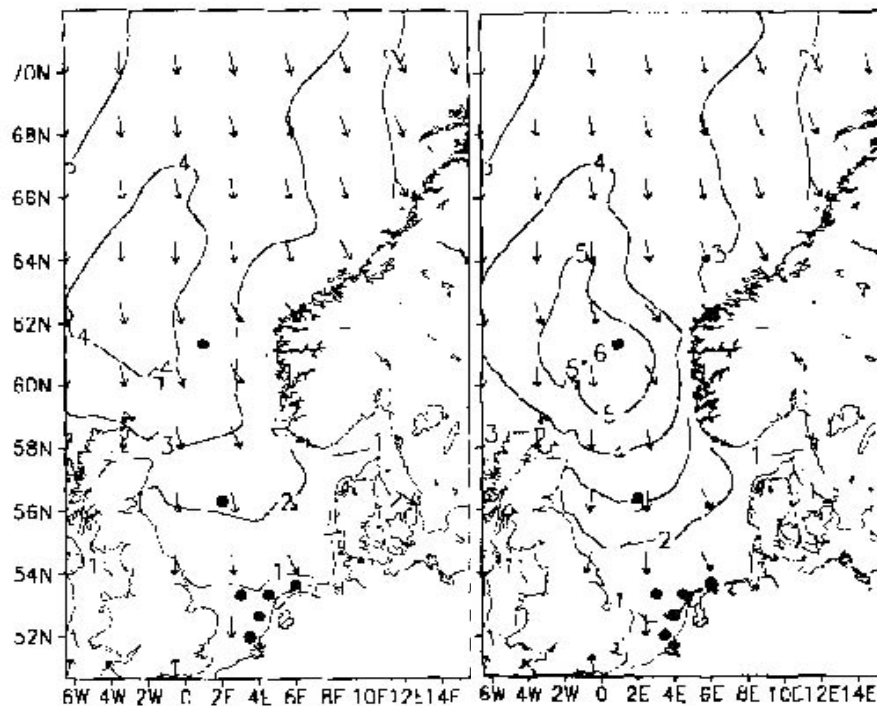
no assimilation

partition of SWH

2-D spectra from SAR and buoys

SeaSat, GeoSat

SAR, buoys



## Techniques:

addition of increments to 1st guess field of wave height;

OI;

4-D variational assimilation, adjoint techniques, Kalman filtering

✓ Impact of wave observations should be introduced in wind field as well -> two way coupling between atmosphere and waves

✓ Multi-variate OA scheme, joint assimilation ?

# WIND WAVE DATA NEEDED FOR WAVE FORECASTING AND VERIFICATION

- IN SITU MEASUREMENTS, INCLUDING 2-D SPECTRA FOR MODEL VALIDATION
- ALTIMETER WAVE MEASUREMENTS FOR VALIDATION AND DATA ASSIMILATION
- SAR WAVE SPECTRA FOR ASSIMILATION INTO NWP MODELS
- SCATTEROMETER VECTOR WIND DATA FOR ASSIMILATION INTO NWP MODELS
- SSM/I WIND SPEED DATA FOR ASSIMILATION INTO NWP

# Wind Wave Climate Studies

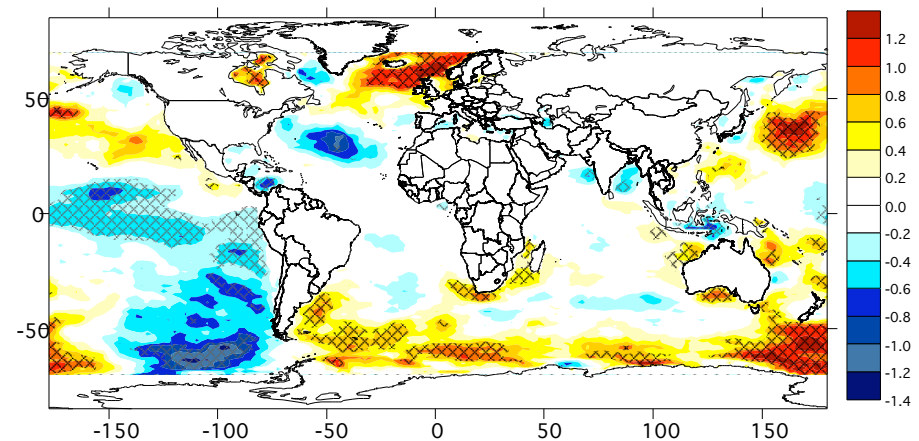
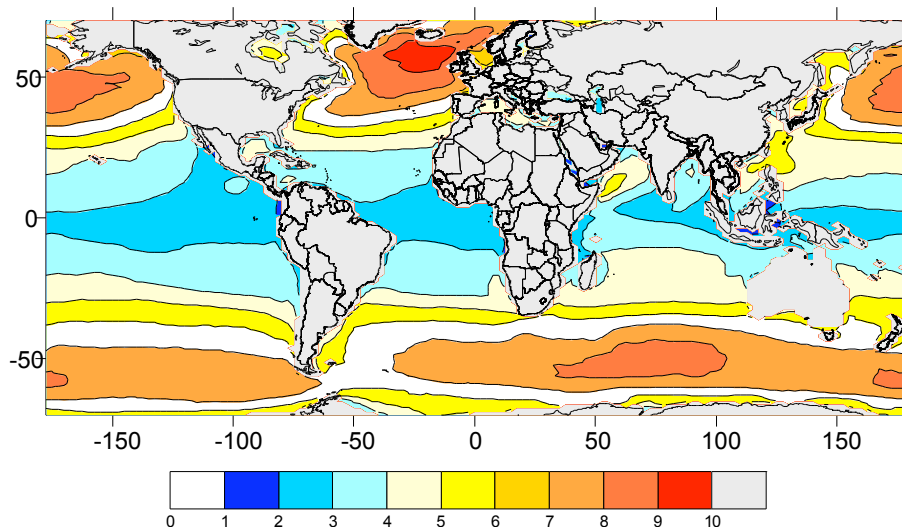
Engineering applications: increasing use of longer return period criteria (e.g.  $10^{-4}$  year wave), spectral (1-D and 2-D) data, overall sophistication of requirements

Validation: buoys, altimeter, SAR data

Climate studies: wave field is a good proxy for storm tendencies

Techniques: hindcasts with high quality wind fields and a proven spectral wave model, mostly based on Reanalyses

99th Percentile Wave Height (m) 1958-1997 (Annual)



## Wind Wave Climate Studies

- ✓ • It is critical for climate uses that each data set be accompanied with a comprehensive set of metadata describing the instrumentation, its characteristics, processing, calibration, and changes in those elements, for example sensor drift.
- ✓ • Wherever possible, new measurement systems should have an overlapping period with the systems they replace.
- ✓ • R&D is required into 4-D variational assimilation systems to effectively handle assimilation of SAR spectra and winds, altimeter and scatterometer data, for future reanalysis systems; this also has obvious application to present real-time NWP forecasting.
- ✓ • R&D into calibration and validation of satellite winds and waves in extreme storm seas (winds  $> 20$  m/s; waves  $> 8$  m) is required.
- ✓ • R&D on homogeneity assessment of all data sets used for climate trend and variability analysis, including model waves, satellite waves and measured waves from buoys and platforms is required.

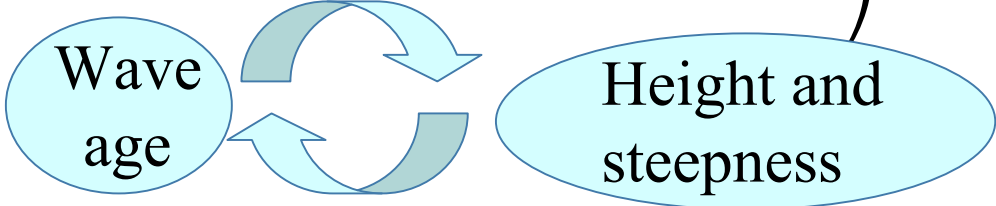
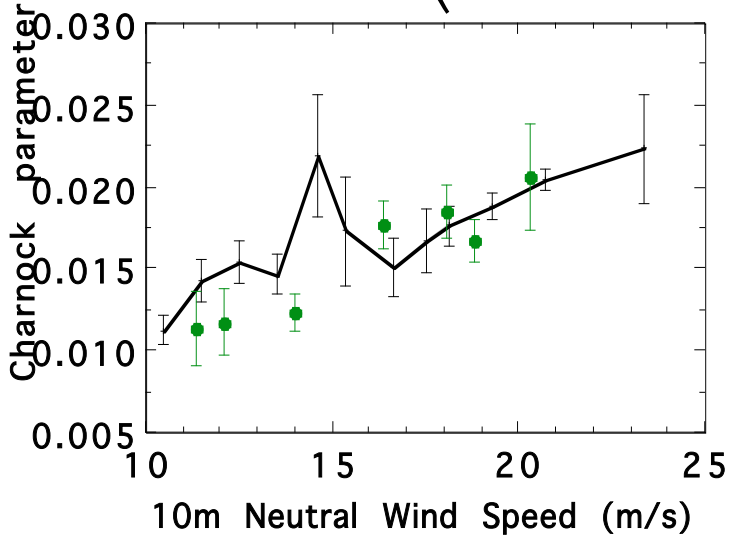
## Role of wind waves in the coupled atmosphere/ocean system **Wind waves 1**

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The Role of Wind Wave in the Atmosphere/Ocean System  
Physical Parameterizations

?

$$\vec{\tau} = f\left(\vec{u}(\vec{r}, t), \text{stability}, F(\vec{r}, t, \vec{k})\right)$$



Evidence surface waves have an effect but exact nature and significance still subject of debate. Alternative wave effect parameterizations; can these effects be parameterized in terms of local, instantaneous wind speed alone?



Need good 2-D wave spectrum observations co-located with other relevant measurements



## The role of waves in air/sea interaction and their dynamical consequences

- ✓ • Wave data may be needed for use of improved physical descriptions of upper-ocean mixing. A consistent description of fluxes in the lower atmosphere, the upper ocean and through the interface is also needed.
  - Combine flux and other routine measurements with observations
- ✓ of the 2-D wave spectrum. It is useful to install instruments capable of measuring the 2-dimensional wave spectrum at the Surface Reference Sites. Wind wave observations should be conducted (as a rule) in parallel with other basic marine surface observations.
  - R/D on coupling a wave model with ocean/atmosphere models
- ✓ both in the data assimilation cycle and forecast modes and on benefit of using wave data in a multivariate objective analysis of observations of the atmosphere, the upper ocean and their interface.

## Wind waves in the GOOS - conclusions and suggestions

- ✓ • Sea state is an important climate variable, not less important than SST or sea level.
- ✓ • Wind wave observations and data services should be a core activity of the GOOS Services module. They are of great value for the GOOS Coastal and Climate modules. Common interests exist of wave data services and of HOTO and LMR modules.
- ✓ • Co-ordination of wave-related GOOS implementation activities should be included in the ToR of the WMO CMM Subgroup on Wave Modelling and Forecasting, now a part of JCOMM. A scientific support group (under SCOR?), is also highly desirable.
- ✓ • Capacity building could focus on technical support in establishing an in situ monitoring network, making wave observation available to the GTS in near real time, and development of national systems for wave forecasting .
- ✓ • Determination of the optimum global observing system for waves is still a work in progress; it should be continued on a quasi-permanent basis in future.





## Excerpt from ETWS-I Meeting Report June 2003 Halifax with respect to GOOS

7.3.1 The meeting agreed that the Team would be pleased to provide suggestions, as requested, to OOPC and/or GOOS Coastal Ocean Observing Panel (COOP) when an observational network, such as selection of a subset of in situ wave buoys for ground calibration for satellite and/or wave models, was designated within the GOOS context.

7.3.2 The meeting urged that the network of in situ wave observations from moored buoys be enhanced, particularly for offshore locations and in the tropics and southern ocean, in order to provide more balanced geographical coverage and therefore more representative statistics in the validation of wave model output and calibration of satellite sensors.

7.3.3 The meeting agreed that the Team should maintain and enhance liaison with major international programmes and their individual components, such as GOOS, OOPC, COOP, GODAE, by participating in organizational or technical meetings on an opportunistic basis or on request.

7.3.4 The meeting recalled that the former CMM Subgroup on Wind Waves had an invited presentation at the OceanObs99 (St Raphael, France, October 1999), a major achievement of the OOPC. The meeting agreed that the Team should make a similar contribution to the follow-on to OceanObs99, whenever this might occur. (**Action:** ETWS members)