The role of RO in the global observing system

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The role of RO in the global observing system

- The WMO and global observing system(s)
  - WIGOS
  - Rolling Review of Requirements (RRR) process
  - “Vision for the GOS in 2025”
  - Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)
  - RO within WIGOS

- The role of reference and anchoring networks

- The role of RO – some thoughts

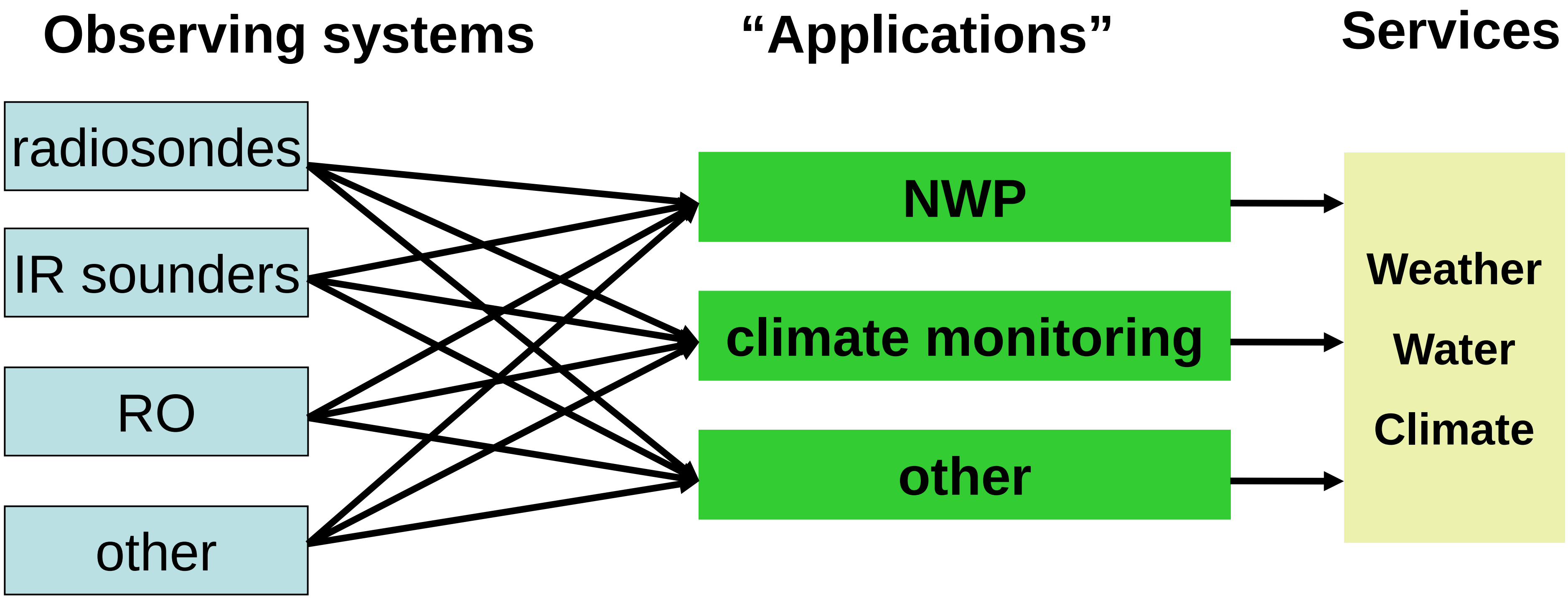
WIGOS:
WMO Integrated Global Observing System

- … responds to observational needs of all WMO programmes and co-sponsored programmes

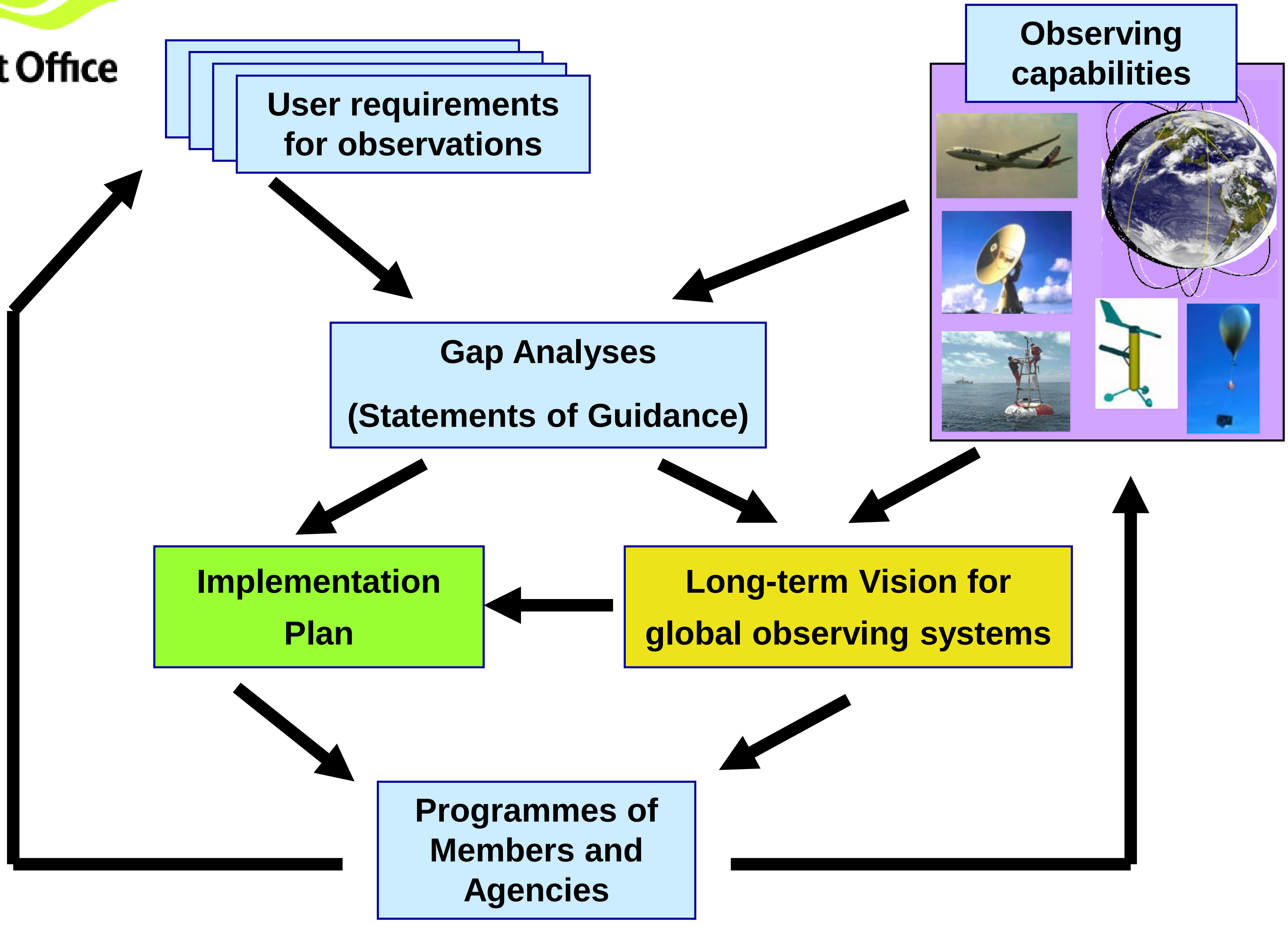
- … brings together formerly separate composite observing systems:
  - GOS (incl. AMDAR), GAW, WHYCOS, GCW/CryoNet, …

- What is WIGOS?
  - "form": management, governance, QM, Manual, Guide, …
  - "content": component observing systems – what should be measured and how

What is WIGOS trying to achieve?



The WMO/CBS **RRR** process:
Rolling Review of Requirements



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RRR process: Application Areas

Global NWP
High-resolution NWP
Seasonal and Inter-Annual Forecasting (SIAF)
Nowcasting
Climate Monitoring (GCOS)
Ocean Applications
Aeronautical Meteorology
Atmospheric Chemistry
Agricultural Meteorology
Hydrology
Space Weather

RRR process: documentation

OSCAR (Observing Systems Capability Analysis and Review Tool)

User requirements:

http://www.wmo-sat.info/oscar/requirements

Space-based observing capabilities:

http://www.wmo-sat.info/oscar/spacecapabilities

Surface-based observing capabilities:

to be constructed

Gap Analyses (Statements of Guidance, SoGs)

http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html#SOG

Vision for the GOS in 2025

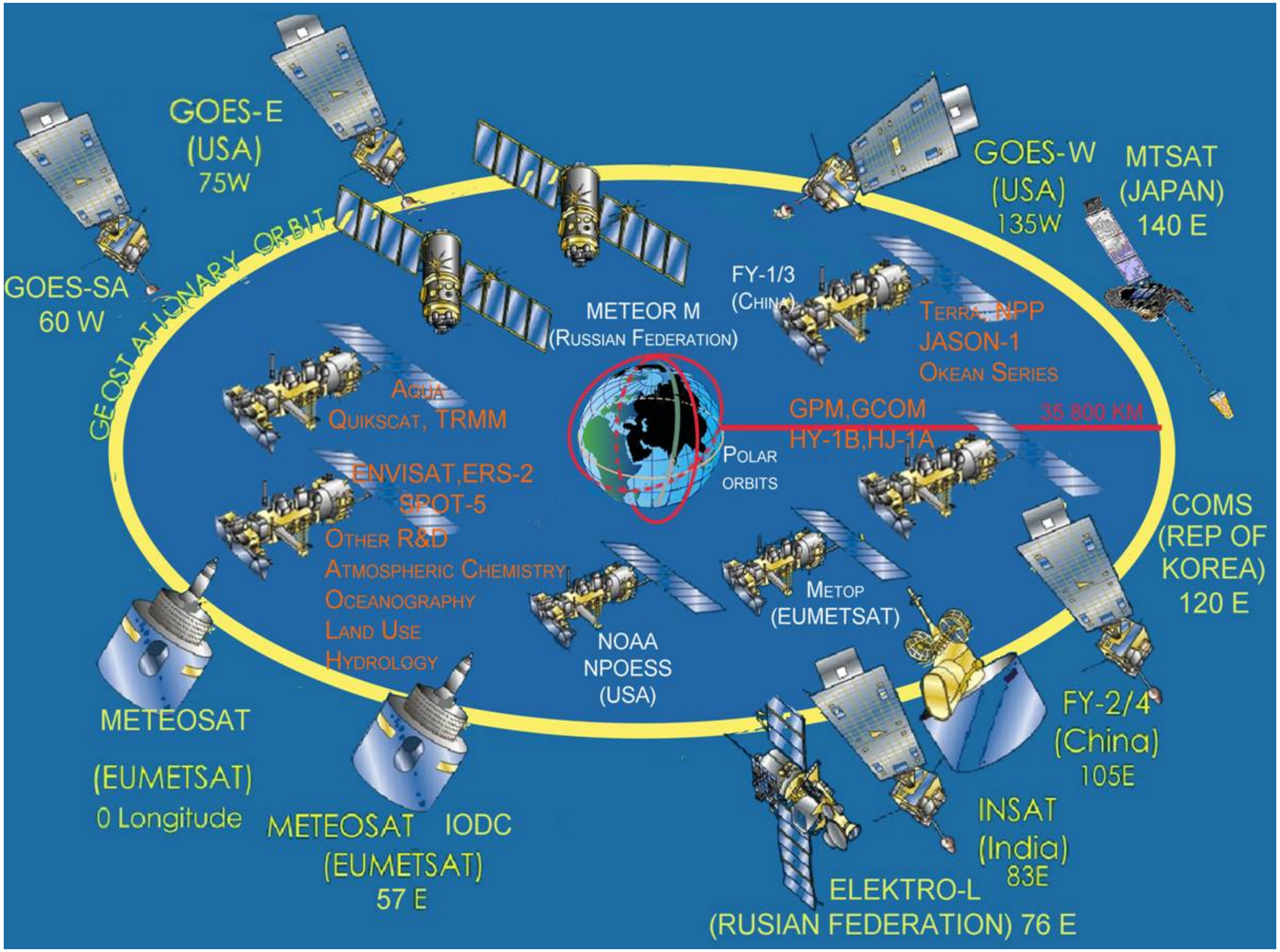
- → Vision for WIGOS component observing systems in 2025

- General themes and issues
  - Response to user needs
  - Integration
  - Expansion
  - Automation
  - Consistency and homogeneity

- Space-spaced observing system

- Surface-based observing system

Vision - space-based component (1)



Vision - space-based component (2)

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Operational geostationary satellites

– at least 6 – each with:

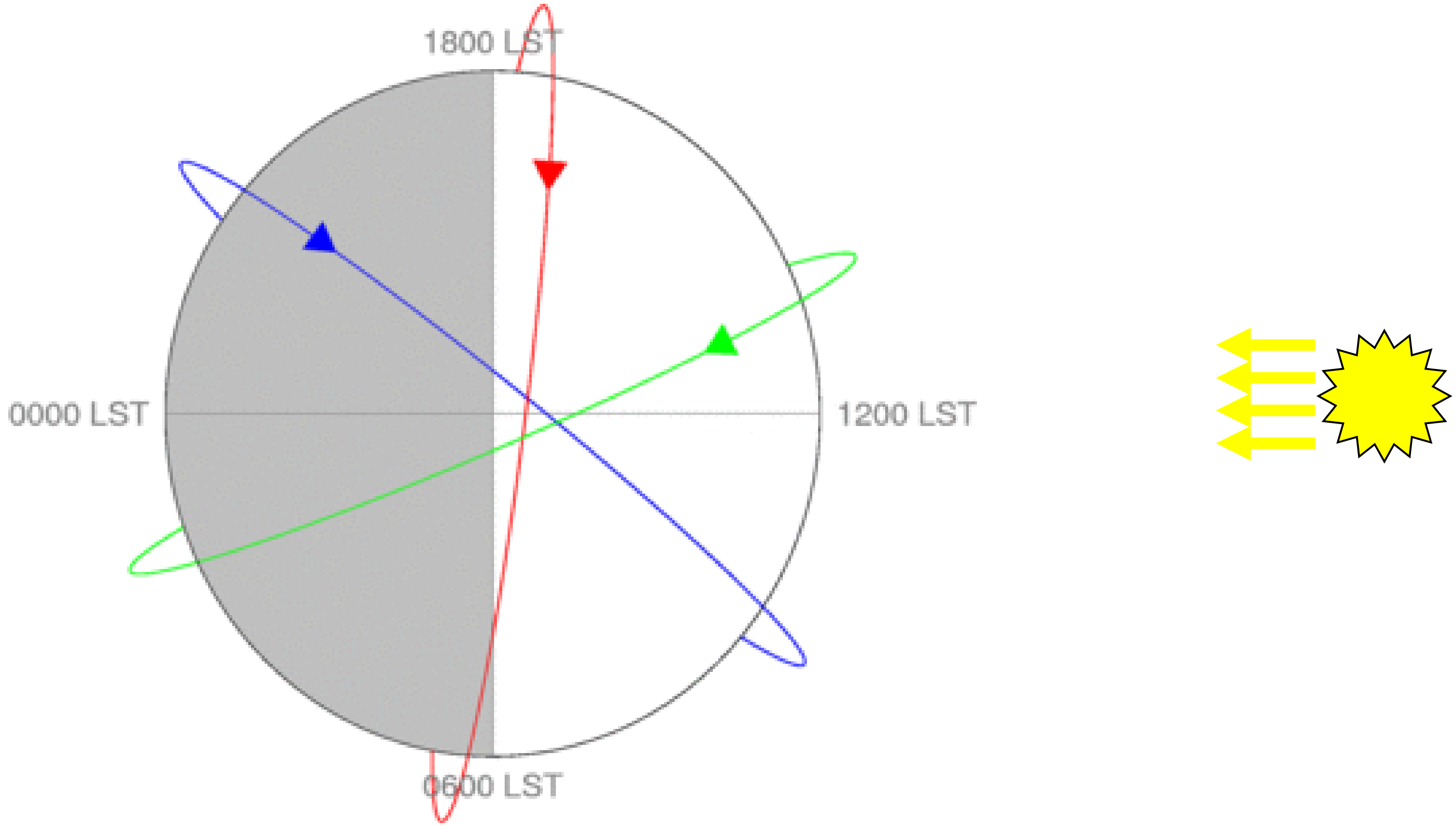
- Infra-red/visible multi-spectral imager
- Infra-red hyper-spectral sounder
- Lightning imager

Operational polar-orbiting sun-synchronous satellites

- in 3 orbital planes – each with:

- Infra-red/visible multi-spectral imager
- Microwave sounder
- Infra-red hyper-spectral sounder

Vision for operational LEO satellites



- approved by WMO-EC, 2009
- recommended baseline with in-orbit redundancy

Vision - space-based component (3)

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Additional operational missions in appropriate orbits:

- Microwave imagers
- Scatterometers
- **Radio occultation constellation**
- Altimeter constellation
- Infra-red dual-view imager – sea surface temperature
- Advanced visible/NIR imagers – ocean colour, vegetation
- Visible/infra-red imager constellation – land-surface
- Precipitation radars
- Broad-band visible/IR radiometers – radiation budget
- Atmospheric composition monitoring instruments
- Synthetic aperture radar

GOS - space-based component (4)

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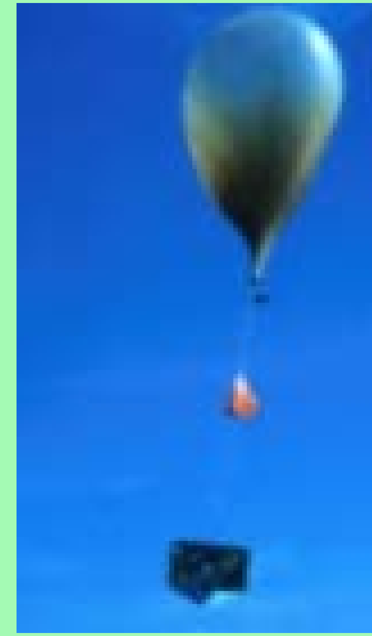
Operational pathfinders and technology demonstrators:

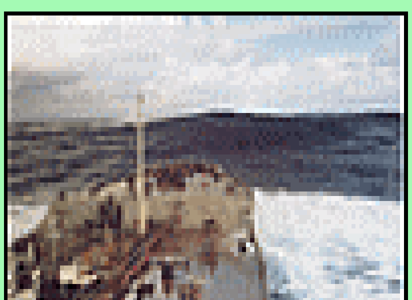
- Doppler wind lidar
- Low-frequency microwave radiometer – salinity, soil moisture
- Microwave imager/sounder on geos - precipitation
- Advanced imagers on geos
- Imagers on satellites in high-inclination, elliptical orbits
- Gravimetric sensors – water: lakes, rivers, ground

Polar and geo platforms/instruments for space weather

- for solar imagery, particle detection, electron density

GOS - surface-based component (1)





GOS - surface-based component (2)

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Land – upper-air

- Upper-air synoptic and reference stations
- Aircraft
- Remote-sensing upper-air profiling stations
- Atmospheric composition stations
- GNSS receiver stations

Land – surface

- Surface synoptic and climate reference stations
- Lightning detection system stations
- Atmospheric composition stations
- Application-specific stations (roads, airports, agromet., urban met., …)

GOS - surface-based component (3)

Land – hydrology

- Hydrological reference stations
- National hydrological network stations

Land – weather radar

- Weather radar stations

Ocean – upper-air

- Automated Shipboard Aerological Programme (ASAP) ships

GOS - surface-based component (4)

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Ocean – surface

- Synoptic sea stations – ocean, island, coastal, fixed platform
- Ships
- Buoys – moored and drifting
- Ice buoys
- Tide stations

Ocean – sub-surface

- Profiling floats
- Ice tethered platforms
- Ships of opportunity

GOS - surface-based component (5)

R&D and operational pathfinders - EXAMPLES

- GRUAN stations
- UAVs
- Gondolas
- Aircraft – chemistry, aerosols, …
- Instrumented marine animals
- Ocean gliders
- …

Implementation of the Vision

- Vision
  - a realistic aspiration and target for 2025
  - endorsed by WMO/CBS in 2009

- Implementation Plan
  - … for the Evolution of Global Observing Systems, EGOS-IP
  - responds to the Vision
  - provides guidance for Members and partner consortia
  - proposes roles for fulfilling the new Vision
  - sets out “road-map” for achieving it
  - 115 Actions
  - endorsed by WMO/CBS in 2012

EGOS-IP:
Actions most relevant for this Workshop (1)

6.3.3.2 Radio occultation constellation

- [3 paragraphs of text explaining the measurement technique and its strengths]

- Action S21
  - Action: Ensure and maintain a radio-occultation constellation of GNSS receivers on board platforms on different orbits producing at least 10,000 occultations per day (order of magnitude - to be refined by the next Action). Organize the real-time delivery to processing centres.
  - Who: CGMS to lead the action, with TCs, satellite agencies and data processing centres.
  - Time-frame: Continuous.
  - Performance indicator: Number of GNSS occultations per day that are processed in near-real-time.

EGOS-IP:
Actions most relevant for this Workshop (2)

6.3.3.2 Radio occultation constellation

- Action S22
  - Action: Perform OSSEs to evaluate the impact of different numbers of occultations per day, and to estimate the optimal number of daily occultations required.
  - Who: NWP centres, in coordination with CBS (to lead the action) and CAS.
  - Time-frame: Before end 2013.
  - Performance indicator: A number of OSSEs carried out.

- "Another application of the GNSS signals and radio-occultation is the measurement of electron density in the ionosphere. Therefore the future radio-occultation constellations will contribute also to the space weather applications (see section [on Space Weather])."

Vision and EGOS-IP: documentation

Vision for the GOS in 2025:

http://www.wmo.int/pages/prog/www/OSY/gos-vision.html

Implementation Plan for the Evolution of Global Observing systems (EGOS-IP):

http://www.wmo.int/pages/prog/www/OSY/gos-vision.html#egos-ip

EGOS-IP:

Available also in French, Spanish, Russian, Chinese!

6.3.3.2 Constelación de sensores de ocultación radio

…

Medida S21

- Medida: Garantizar y mantener una constelación de receptores GNSS de ocultación radio a bordo de plataformas en diferentes órbitas que produzcan al menos 10 000 ocultaciones al día (el orden de magnitud se redefine en la siguiente medida). Organizar la entrega en tiempo real a los centros de procesamiento.
- El GCSM dirigirá la medida, en colaboración con Comisiones Técnicas, organismos de satélites y centros de procesamiento de datos.
- Plazo: Continuo.
- Indicador de ejecución: Número de ocultaciones GNSS al día procesadas en tiempo casi real.

RO within WIGOS

- NWP
  - demonstrated impact on NWP skill
  - high impact/observation, high impact/cost
  - impact still increasing linearly with number of occultations
  - demonstrated role as “anchor” observations

- Climate monitoring
  - demonstrated all-weather, near-homogeneous monitoring
  - potential as a major contribution to CDRs for GCOS ECVs
  - potential as “reference” observations

- Space weather
  - global 3D monitoring of electron density

The role of reference and anchoring networks

Observing System Network Design Principles for WIGOS (1)

- Draft OSND Principles now available (April 2014)
- Part of new “WIGOS Manual”
- Under review by WMO Technical Commissions and Members

Observing System Network Design Principles for WIGOS (2)

1. Serving many application areas
2. Meeting user requirements
3. Meeting national, regional and global requirements
4. Designing appropriately spaced networks
5. Designing cost-effective networks
6. Achieving homogeneity in observational data
7. Designing through a tiered approach
8. Designing reliable and stable networks
9. Making observational data available
10. Providing information so observations can be interpreted
11. Achieving sustainable networks
12. Managing change

Observing System Network Design Principles for WIGOS (3)

7. DESIGNING THROUGH A TIERED APPROACH

- Observing network design should use a tiered structure, through which information from reference observations of high quality can be transferred to and used to improve the quality and utility of other observations.

Bias correction of observations for NWP and Reanalysis

Which observations?

- in principle, all observation except “anchor” observations
- crucial for satellite radiances

How?

- using statistics of (O-B) →

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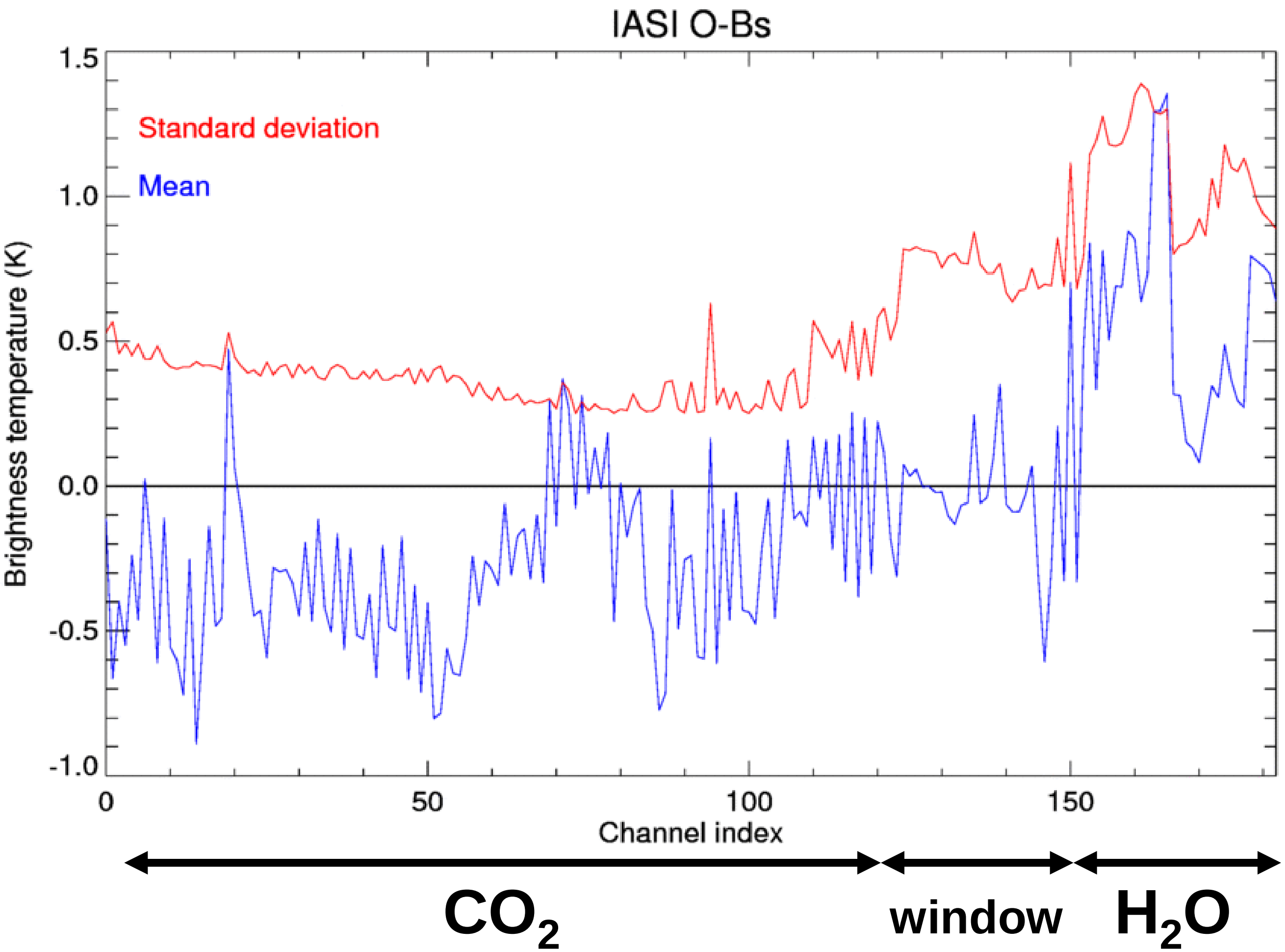
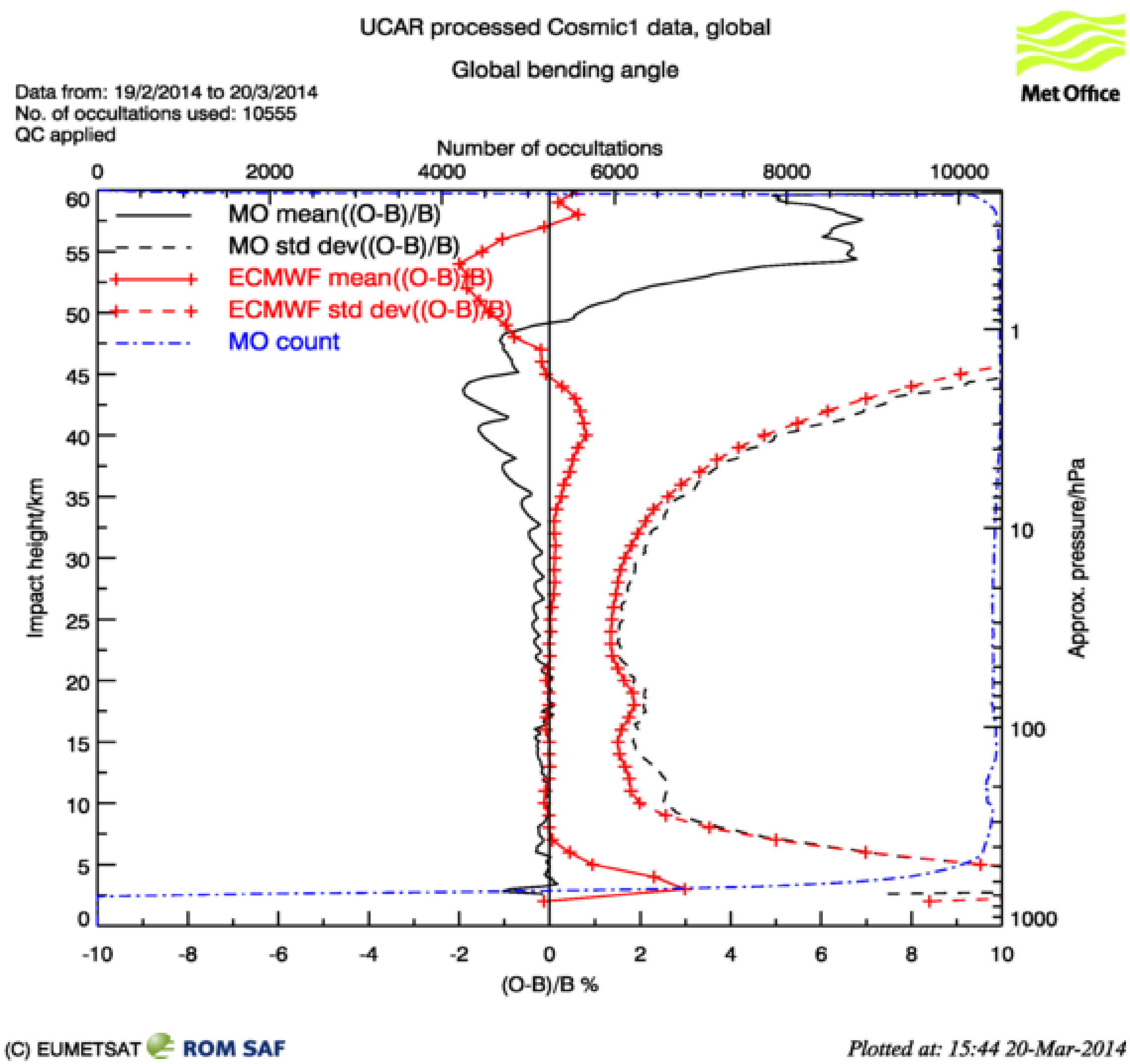
Monitoring IASI data against NWP model



Statistics of differences between obs and NWP model equivalents

- global data
- 12730 obs
- 6-hours' data (30 Jan 2013)
- operational qc
- cloud-free

Monitoring NWP model biases using RO data



Statistics of differences between obs and NWP model equivalents

" (O-B) / B "

=

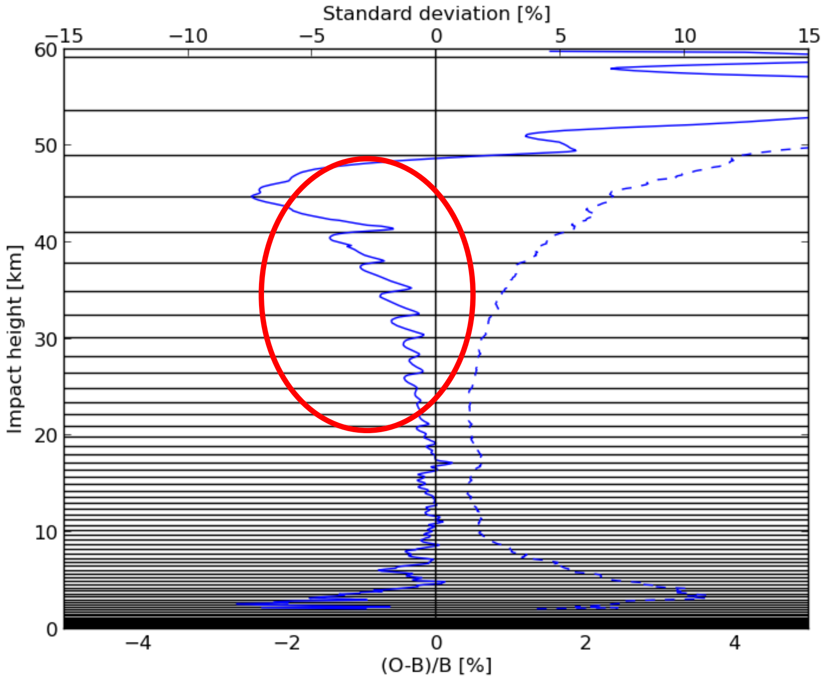
$(y^o - H[x^b]) / H[x^b]$

30 days

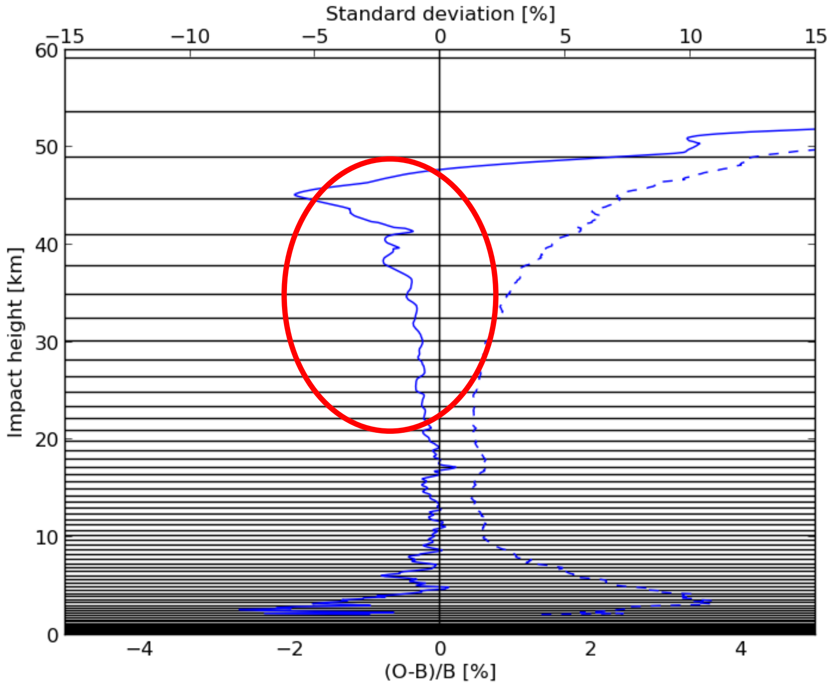
10555 obs

Improved forward model for bending angles

An approximation to the dry form of the ‘new’ refractivity variation with height (assuming no moisture) can be integrated analytically in the Abel transform.



Exponential N(x)



‘New’ N(x) (dry)

This **reduces the oscillations** considerably, so by implementing this, the increments will have smaller biases, leading to better analyses and radiance bias corrections.

The improved bending angle and refractivity operators will be available in **ROPP 8.0** (end of 2014).

From Chris Burrows (Met Office)

Anchor and reference observations

Anchor observations, e.g.

- selected sondes (night-time Vaisala? → GRUAN?)
- GNSS-RO
- selected radiances, e.g.
  - upper stratosphere / mesosphere channel(s), e.g. AMSU-A 15
  - selected upper tropospheric humidity channels

Reference observations

- anchor observations that can be traced to standards
- ?observations that are not assimilated?

Desirable characteristics of reference observations

- high quality and reliability – traceable to SI standards
- well-characterised
- available in near-real time (preferable)
- for all key variables of NWP models and covering full NWP model domain
  - surface to mesosphere for temperature
  - surface to lower stratosphere for water vapour
  - wind?

The role of reference and anchoring networks:

the role of RO data – some thoughts

The role of RO data - some thoughts

- RO data already used as anchor obs in NWP and reanalysis
- What more needs to be done: anchor → reference obs?
- What could be their role in improving the impact of GRUAN observations?

GRUAN and potential role of RO

- GRUAN = GCOS Reference Upper Air Network
- GRUAN sites have / will have high-quality radiosondes with well-characterised uncertainties
- 15 GRUAN sites → 30-40 in future
- How to transfer GRUAN quality to other sondes?
  - … to improve sonde bias corrections
  - via NWP (O-B) statistics? Is it good enough?
  - via RO (O-B) statistics close to sonde locations?
  - or similar? – topic for discussion.

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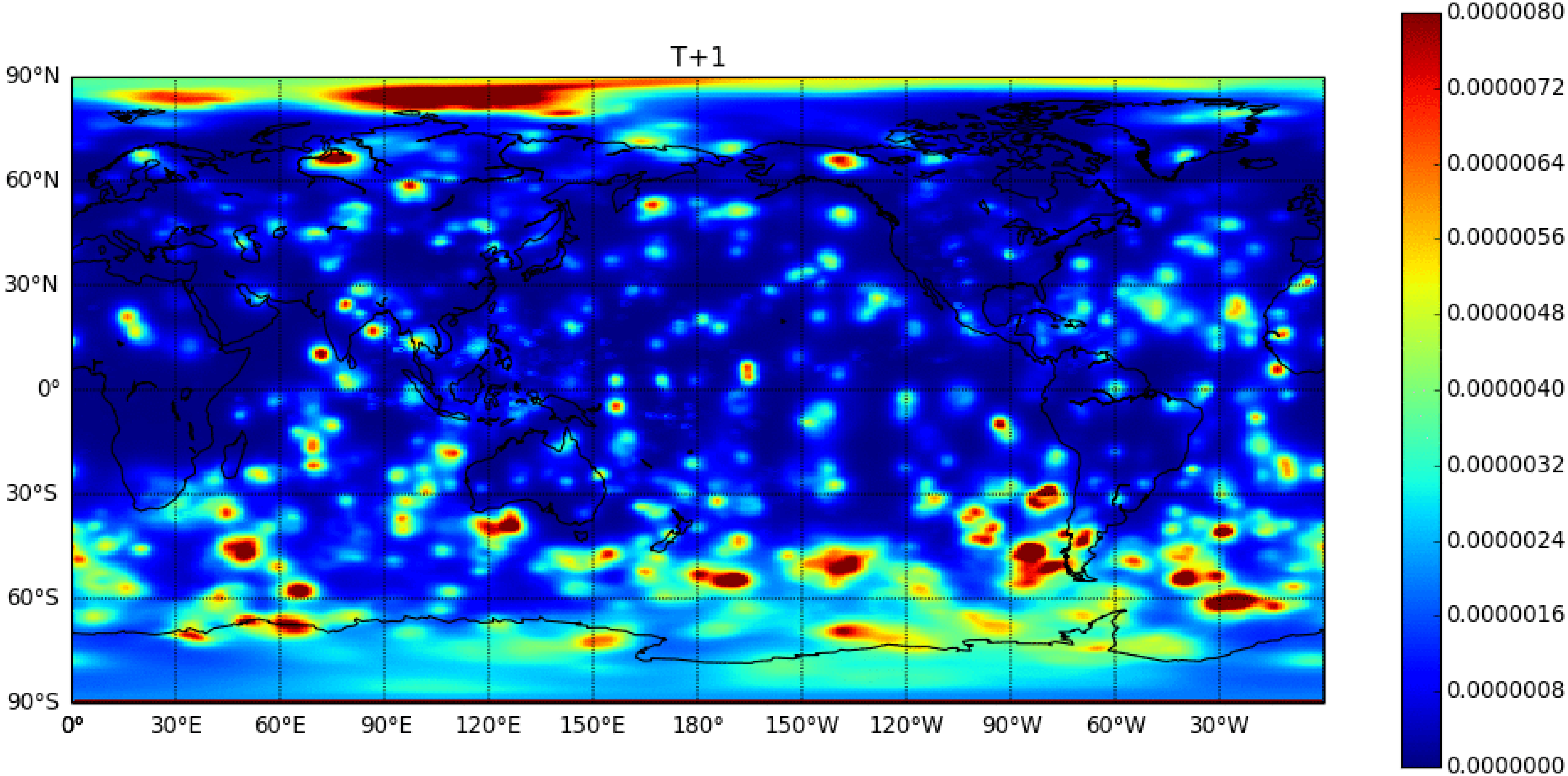
Time evolution of the “impact” of RO on a single NWP cycle



Thank you! Questions?

Vision: general themes and issues (2)

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Response to user needs

- … of all WMO Members and Programmes … weather, water and climate
- … composite and increasingly complementary system of observing systems
- … evolve in response to a rapidly changing user and technological environment

Consistency and homogeneity

- … increased standardization of instruments and observing methods
- … improvements in calibration … and the provision of metadata, to ensure data consistency and traceability to absolute standards

Vision: general themes and issues (3)

Integration

- The GOS .. evolve to become part of WIGOS … to support operational weather forecasting and [now also] other applications: climate monitoring, oceanography, …
- Integration will be developed through the analysis of requirements and, where appropriate, through sharing observational infrastructure, platforms and sensors, across systems and with WMO Members and other partners;
- Surface and space-based observing systems will be planned in a coordinated manner cost-effectively to serve a variety of user needs with appropriate spatial and temporal resolutions.