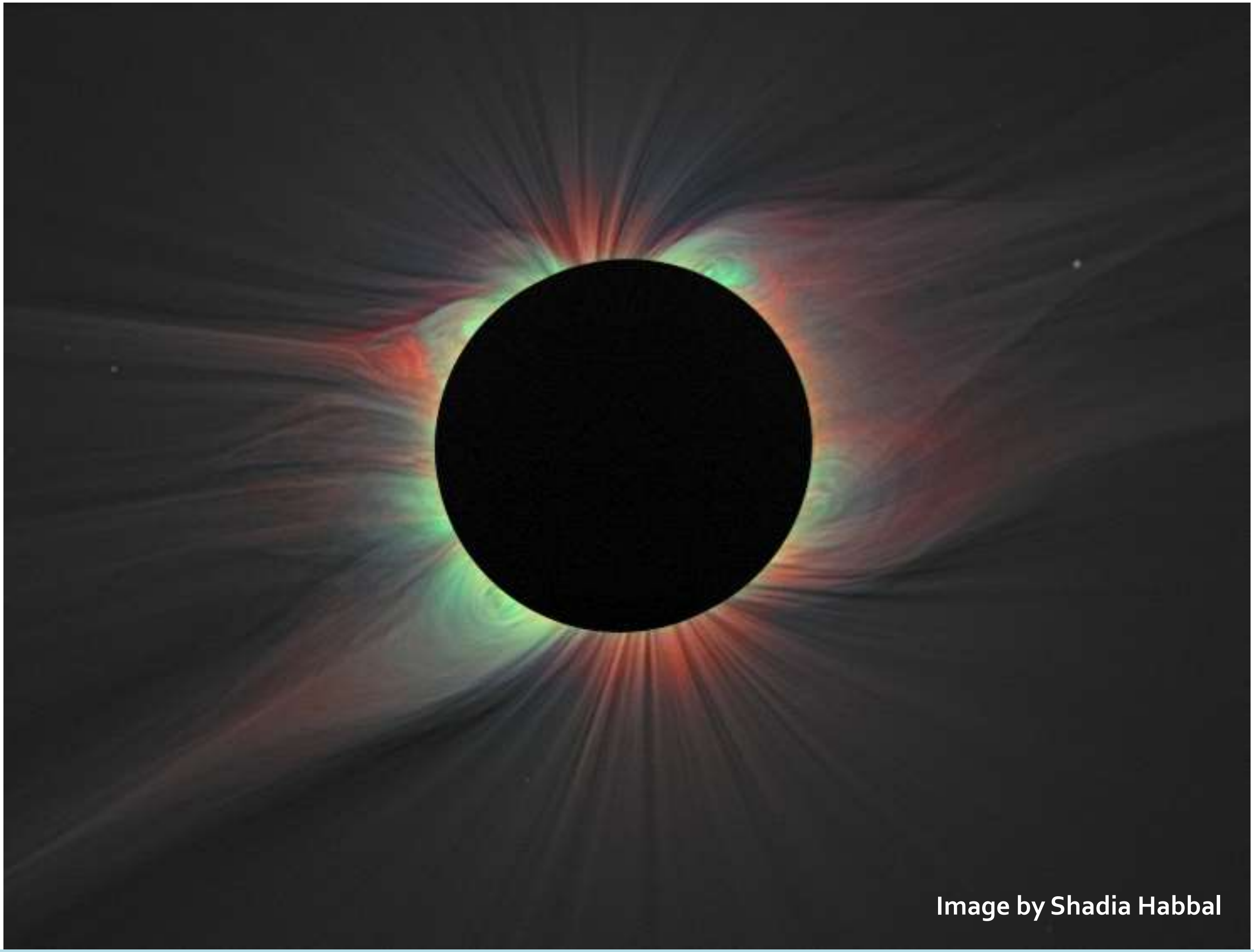
Geospace Sciences (in GEO) update at NSF



PREEVENTS

PREDICTION OF AND RESILIENCE AGAINST EXTREME EVENTS

Natural hazards including space weather

- Enhance understanding of fundamental processes
- Improve capability to model and forecast events

Announced Sep 2015

Two tracks: co-funding and larger projects

Solicitation for Track II expected in May 2016 with deadline in September 2016

Geospace Sciences
Portfolio Review and Motivations

- NRC's Decadal Survey: *Solar and Space Physics – A Science for a Technological Society*, and the "DRIVE" initiative

- Changing needs, e.g. increased focus on Geospace System Science and modeling, and the observations that support that.

- Assessment of state of infrastructure

- Current flat budget and outlook

Portfolio Review Committee Members

Chair

William Lotko
Dartmouth College

GEO/Advisory Committee Liaison

Joshua Semeter
Boston University

Members

Daniel N. Baker
University of Colorado – Boulder

Joseph Huba
NRL

Jorge Chau
Leibniz-Institute of Atmospheric Physics (Germany)

Christina Cohen
California Institute of Technology

Sarah Gibson
National Center for Atmospheric Research

Mona Kessel
NASA/HQ & GSFC

Delores Knipp
University of Colorado – Boulder

Louis Lanzerotti
New Jersey Institute of Technology

Patricia Reiff
Rice University

Alan Rodger
University of Cambridge (UK)

Howard Singer
NOAA/Space Weather Prediction Center

Portfolio Recommendations

Current elements | status quo

Core Grants Programs (AER, MAG, STR): *Maintain current budget share*

Targeted Grants Programs (CEDAR, GEM, SHINE): *Maintain current budget share out to ~2020; transition a portion of the budget thereafter to **IGS** **(SWM, GCP)** **programs***

Faculty Development in Space Sciences (FDSS): *Maintain current budget*

Space Weather Modeling (SWM) Program: *Maintain current budget to 2020; grow thereafter with reprogrammed funds from targeted grants programs*

Facilities Program:

- *Maintain current budgets for 4 "Class 1" facilities (**ISRs at Jicamarca, PFISR, RISR-N, Millstone Hill** less **Madrigal Data Center**)*
- *Maintain current budgets for 4 "Class 2" facilities (**AMPERE, SuperMag and SuperDARN** and **Community Coordinated Modeling Center** (with NASA)*

Portfolio Recommendations

CubeSat Program: *Reduce budget by ⅓ by 2020*

Facilities Program:

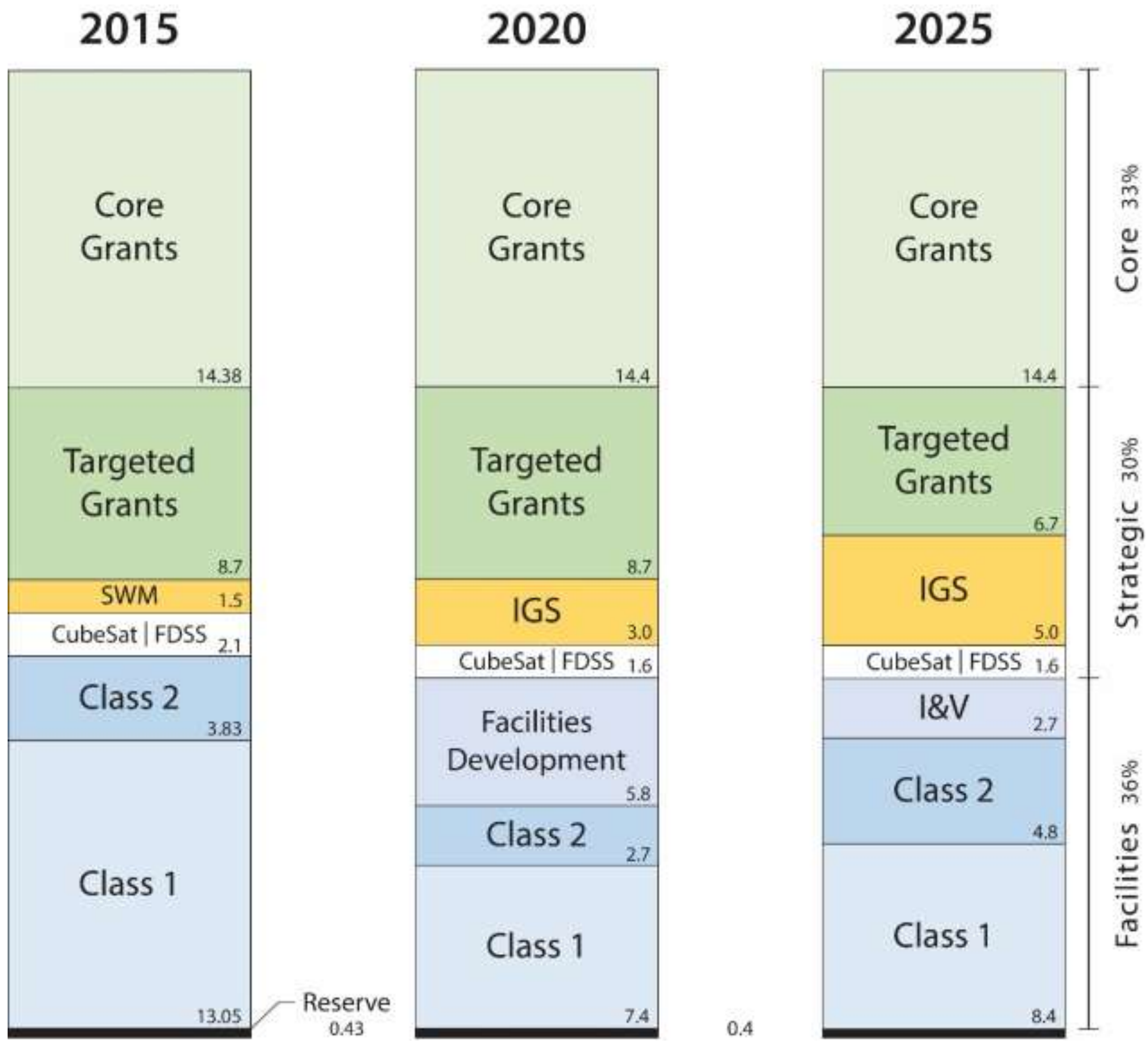
- *Reduce funding for **Arecibo ISR** by ¾ by 2020; ancillary instruments funded via grants programs and peer review*
- *Terminate funding for **Sondrestrom ISR** by 2020; remaining site instruments funded via grants programs and peer review*
- ***Consortium of Resonance and Rayleigh Lidars (CRRL)** to be funded via grants programs and peer review; operates as PI-led project rather than community facility*

Portfolio Recommendations

Redirect funding to 5 new program elements by 2020

- **Grand Challenge Projects:** *Element of* **Integrative Geospace Science (IGS)** *grants program together with* **SWM**
- **Data Systems:** *Facilit(ies) to exploit emerging information technologies for integrated software and data analysis tools, geospace data mining and data assimilation. Peer-reviewed projects receiving support from this program are expected to become Class 2 facilities by 2025*
- **Distributed Arrays for Scientific Instruments (DASI):** *Development of distributed measurement systems. Peer-reviewed projects receiving support from this program are expected to become Class 2 facilities by 2025*
- **Innovation and Vitality:** *Peer-reviewed grants for innovations in facilities and models and upgrades (as needed) to maintain state-of-the-art*
- **European Incoherent Scatter Scientific Association (EISCAT):** *Begin forging a partnership with the EISCAT consortium to use new EISCAT-3D capability and EISCAT-Svalbard as a replacement for Sondrestrom*

Recommended GS Portfolio: 2020 to 2025



NRC "Consensus Study"

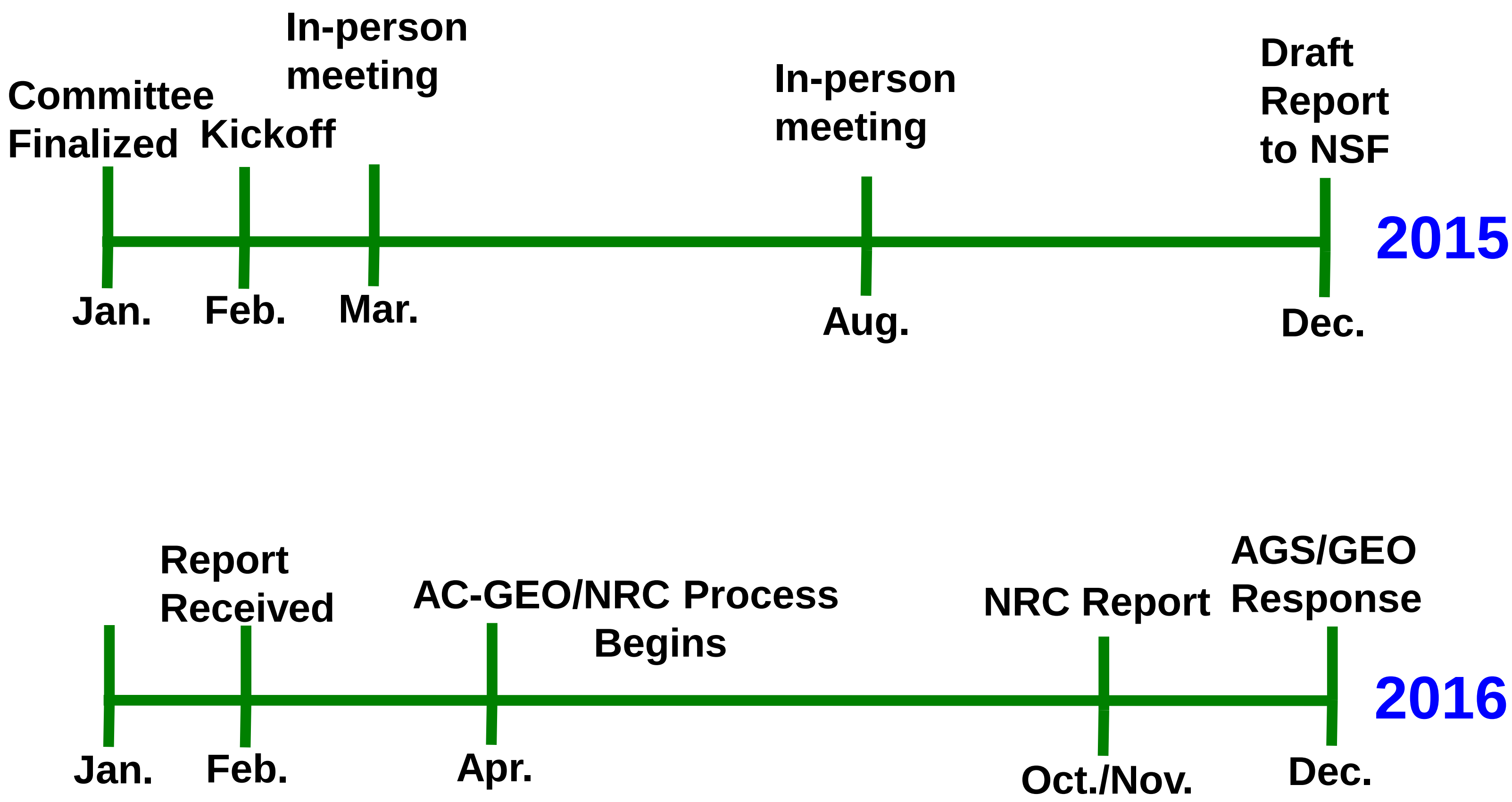
Ad Hoc Committee of the Space Studies Board to Conduct a "Concensus Study" of the Portfolio Review Report.

CS will assess how well the Report's findings, conclusions and recommendations:

1. **Align with the Decadal Survey**
2. **Take into account:**
    a. **Actions already taken in response to the Survey**
    b. **Budget landscape**
    c. **Interdisciplinarity and scientific balance of GS activities**
    d. **Alignment of facilities investments with science needs**
    e. **Integration of technology development**
    f. **Balance of investments between facilities, grants and other GS activities**
3. **Provide a forward-looking focus**
4. **Provide clear recommendations re implementation of the Survey's priorities**

And that the recommendations are unbiased and supported by the available data.

PR Timeline


Committee Finalized
Kickoff
In-person meeting
In-person meeting
Draft Report to NSF
2015
Jan.
Feb.
Mar.
Aug.
Dec.
Report Received
AC-GEO/NRC Process Begins
NRC Report
AGS/GEO Response
2016
Jan.
Feb.
Apr.
Oct./Nov.
Dec.

National Context

NATIONAL SPACE WEATHER ACTION PLAN

PRODUCT OF THE

National Science and Technology Council

October 2015

Space Weather Action Plan Activities
Goal 1: Develop Benchmarks

Phase 1: Initial benchmarks based on existing studies

- NSF Staff contribute to all 5 working groups

Phase 2: Development of Scientifically and statistically rigorous benchmarks

- Developing plans for engaging the scientific community – in collaboration with NASA

Space Weather Action Plan Activities
Goal 5: Advancing Understanding and Forecasting

CEDAR, GEM, and SHINE Programs

- Facilitate research collaboration on coupling and interaction

NASA/NSF Collaborative Space Weather Modeling

- Large-scale modeling efforts that require community teamwork

NASA/NSF Community Coordinated Modeling Center, Goddard

- Development of models for transition to operational use

AMPERE, SuperDARN and SuperMAG

- Global networks of space weather relevant observations

Neutron Monitor network

- Community Workshop to assess current state and future potential Oct 2015; Report expected soon

SuperMAG

AMPERE

Semi-random examples of exciting geospace science developments

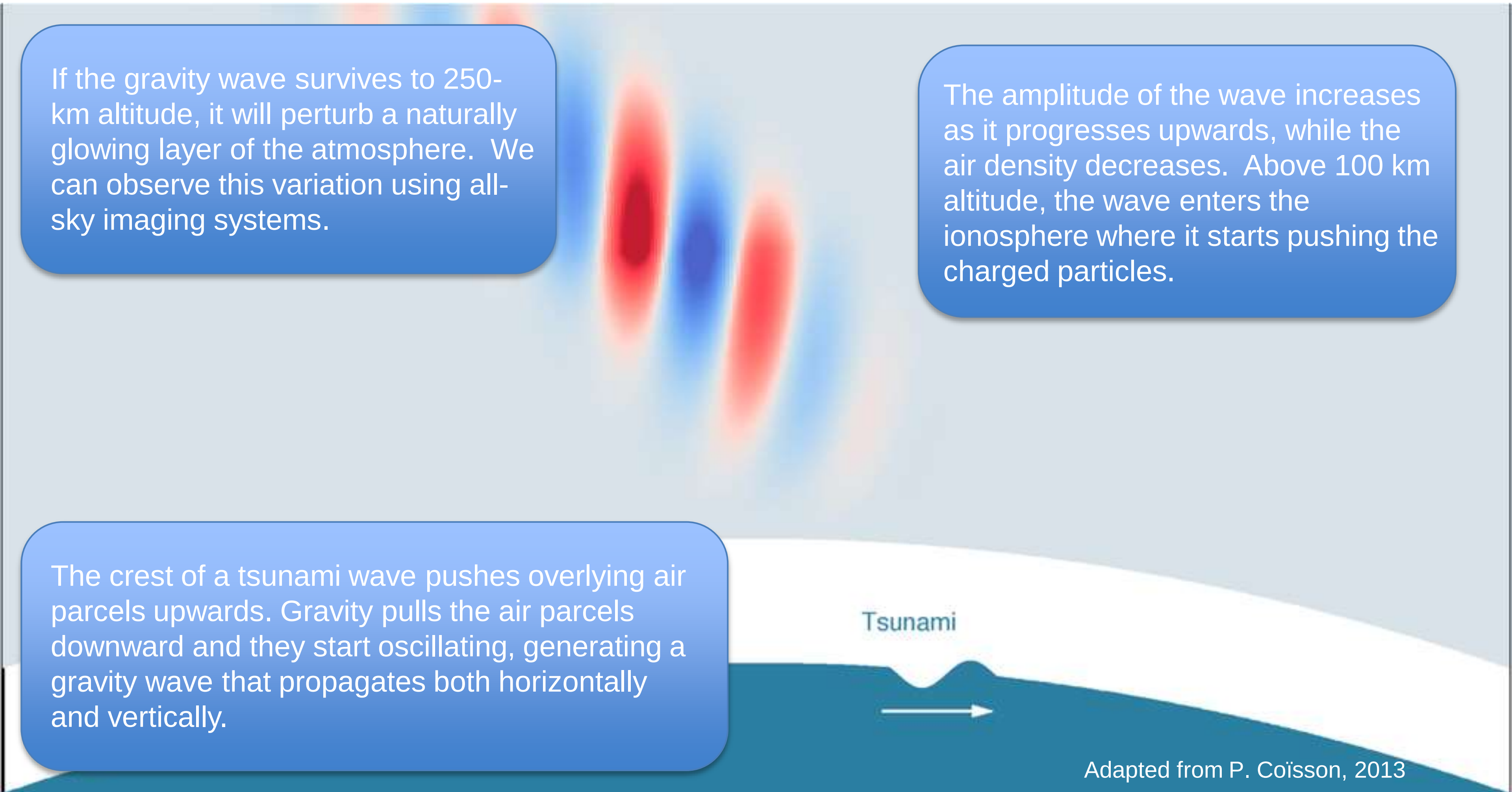
Tsunami-ionospheric coupling

- Recent observations using distributed systems of optical and radio instruments have demonstrated the coupling of the solid earth and ocean to the upper atmosphere during large earthquakes and tsunamis
- Opens up new avenues of research on the propagation of waves in the atmosphere as well as the possibility of monitoring for natural hazards using observations of near-space

If the gravity wave survives to 250-km altitude, it will perturb a naturally glowing layer of the atmosphere. We can observe this variation using all-sky imaging systems.

The amplitude of the wave increases as it progresses upwards, while the air density decreases. Above 100 km altitude, the wave enters the ionosphere where it starts pushing the charged particles.

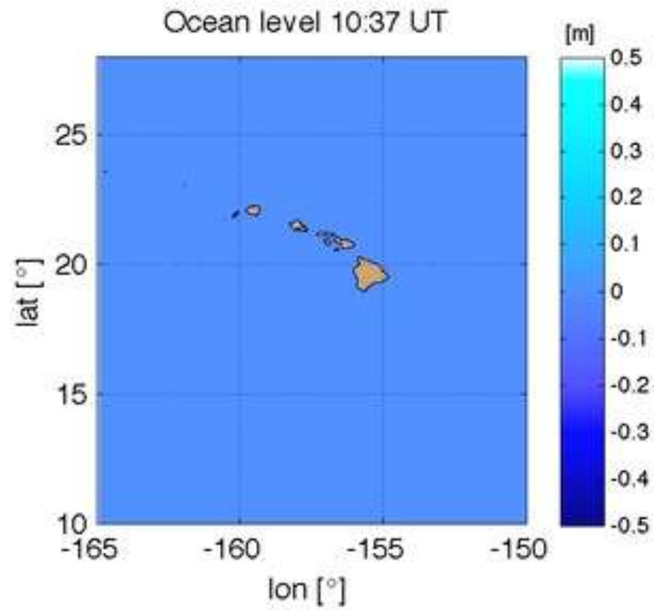
The crest of a tsunami wave pushes overlying air parcels upwards. Gravity pulls the air parcels downward and they start oscillating, generating a gravity wave that propagates both horizontally and vertically.

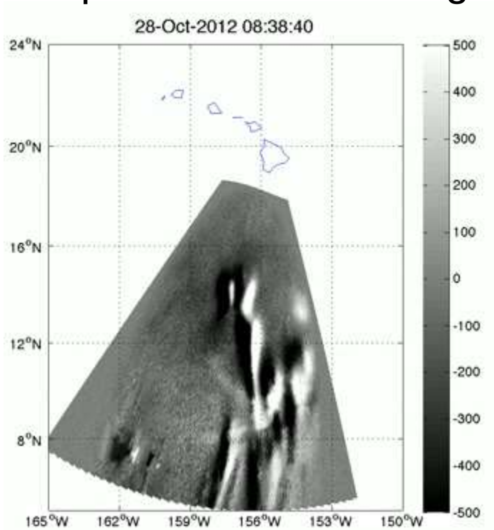


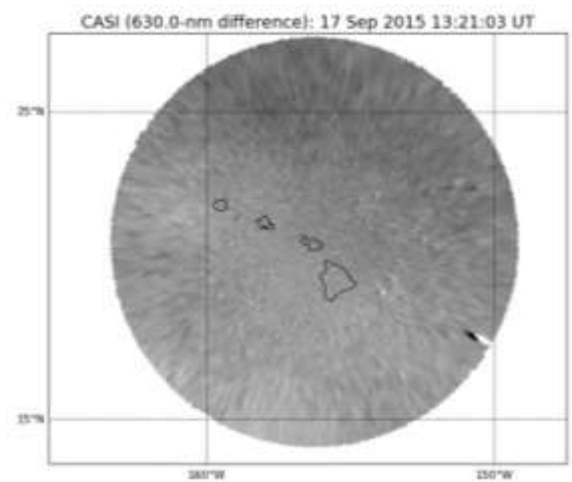
Adapted from P. Coïsson, 2013

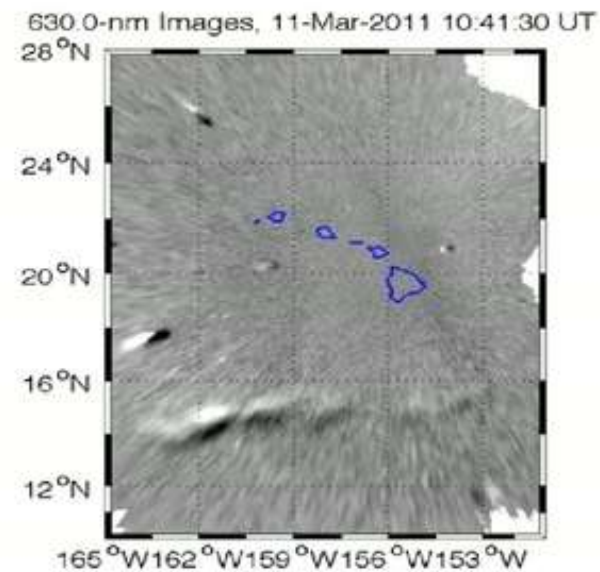
Airglow observations of tsunami-ionospheric coupling

- First observation of the airglow signature of a tsunami was made after the Tohoku earthquake of 11 March 2011
  - Airglow signature observed from Hawaii one hour in advance of the tsunami arrival in Hawaii
  - Waves in the airglow move coherently with the ocean waves and share characteristics (wavelengths, orientation, etc)
- Subsequent observations confirm this first observation
  - 2012 Haida Gwaii tsunami (28 October 2012)
  - 2015 Chile tsunami (17 September 2015)
- International team from the ocean, atmospheric, and space sciences communities currently developing models to improve understanding of coupling mechanisms



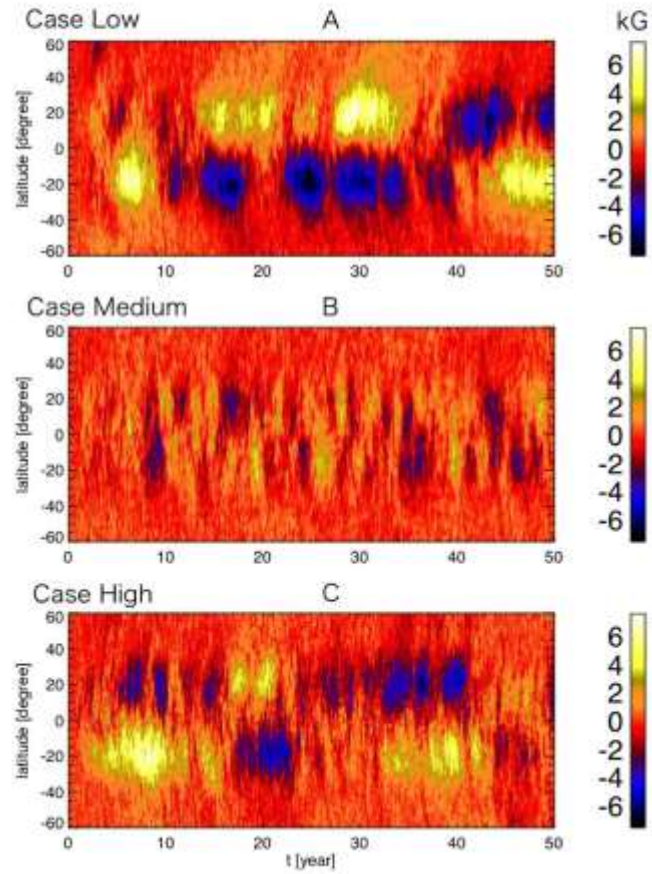






Super-resolution solar model achieves order out of chaos

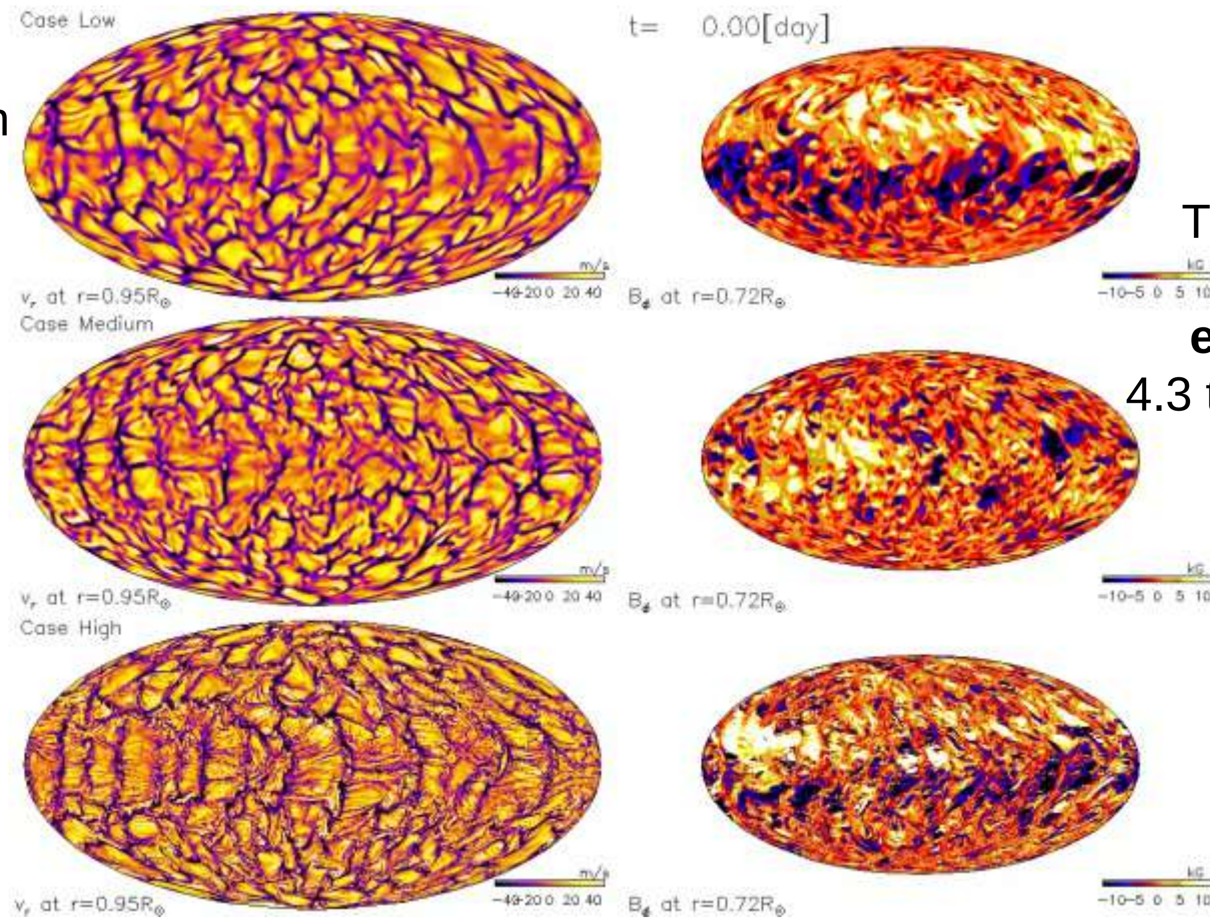
- Background:
  - Maintenance of a coherent large-scale magnetic field in a highly turbulent system (i.e. coherent 11 year solar cycle)
  - Previous simulations suggested coherence is lost at higher resolution
- Focus of study:
  - Series of global dynamo simulations exploring the influence of resolution and effective diffusivity
  - Reproduces previous results at low and medium resolution (A, B), i.e. loss of coherence at intermediate resolution
  - Coherence is regained at 4 times higher resolution (C)
- Take away:
  - Turbulent magnetic field at small scales mimics the effect of strong viscosity through magnetic stresses
  - High resolution simulations with resolved small-scale field behave similar to a low resolution simulation with high viscosity
  - Efficient small-scale dynamo crucial for large-scale dynamo in a highly turbulent system



Visualization of magnetic field at base of simulation domain as function of time "butterfly diagram". The low and high resolution cases (A & C) show a similar coherence whereas the coherence is lost at intermediate resolution (B). (From Hotta et al. 2015, Science 351, 1427).

Super-resolution solar model achieves order out of chaos

Nominated for the Association for Computing Machinery Gordon Bell Prize



The largest fluid simulation **ever** attempted
4.3 trillion grid points.

Used NWSC/Yellowstone completely and 90% of the memory of the Japanese “K Computer” (more than 1.5 PB)

[Hotta et al. 2015, Science 351, 1427]