A view toward physical and biogeochemical ocean data assimilation at the sub-mesoscale

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Outline

• DA at the submesoscale as an emerging challenge
• Phenomenology & processes
• Prospects for observing the submesoscale
• Challenges for data assimilation
The Ocean Submesoscale

(Munk et al., 2000; Thomas et al., 2008; Klein and Lapeyre, 2009; Lévy et al, 2012)
Frontal features are ubiquitous

Frontogenesis

Bergerson (1967); Hoskins (1982)

A field of mesoscale eddies

Strain-induced

Shear-induced

Conditioned by the mesoscale circulation
Evolution

**Unforced**

\[ R_o \sim O(1) \]

\[ L \sim 1 \text{ km} \]

\[ U \sim 0.1 \text{ m s}^{-1} \]

“Eady” instability

(eg. Molemaker et al, 2005)

**Buoyancy Forced**

\[ \alpha = N h_{ml} / f \]

(Legg et al., 1998)

**Wind Forced**

Ekman transport

(Thomas and Lee, 2005)
Ocean Biogeochemistry

Lévy et al. (2012)

Aggregation and Community Structure

Upwelling and downwelling

Phytoplankton (Lévy et al., 2012)
Zooplankton (Limouzy-Paris et al., 1997)
Birds (Tew Kai et al., 2009)
Cetaceans (Cotté et al., 2011)
Observing the Submesoscale

Lévy et al. (2012)

Remote sensing:
- SST
- Ocean color

In situ: glider
- Temperature
- Chlorophyll

Challenges:
- Short-lived (hours-days)
- Small scale (~1-10 km)
Observing the Submesoscale

HF radar (Shay et al, 2003)

SAR (McWilliams et al, 2009)

SWOT (NASA, CNES, CSA, UKSA) (15 km)

Ocean gliders, AUVs & drifters

Aircraft (hyperspectral imagers, altimeters, lidar)

NSF OOI (endurance arrays)
Challenges for Data Assimilation

- High resolution models
- Nested grids
- Complex non-linear circulations
- Inhomogeneous, anisotropic, flow dependent covariances
- Unconventional data types (SAR & visible images)
- Biochemical tracers have non-Gaussian errors
- Submesoscale time scales similar to IG waves (initialization?)
- Balance relations (SG, SQG?)
- Hybrid DA probably the way to go
- Var limited by tangent linear assumption
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Gfactor = 3  Lmin = 45  Lmax = 137  Jmin = 42  Jmax = 126

DXmin = 0.777  DXmax = 0.78  DYmin = 0.775  DYmax = 0.778  Lm = 276  Mm = 252
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