Sea Level Rise Predictions

Patrick Barnard
USGS Pacific Coastal and Marine Science Center, Santa Cruz, CA

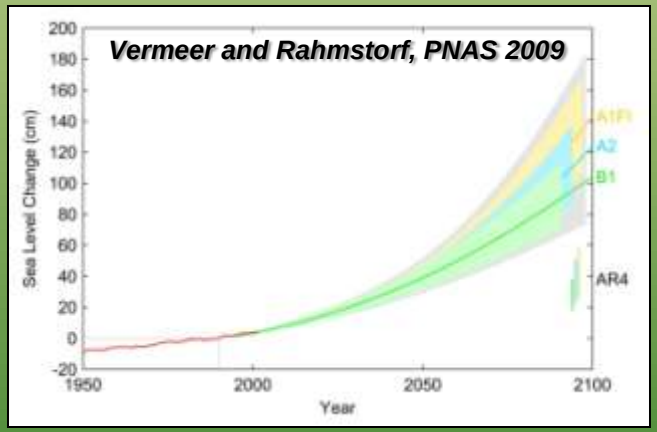
USGS
science for a changing world

Global Trends

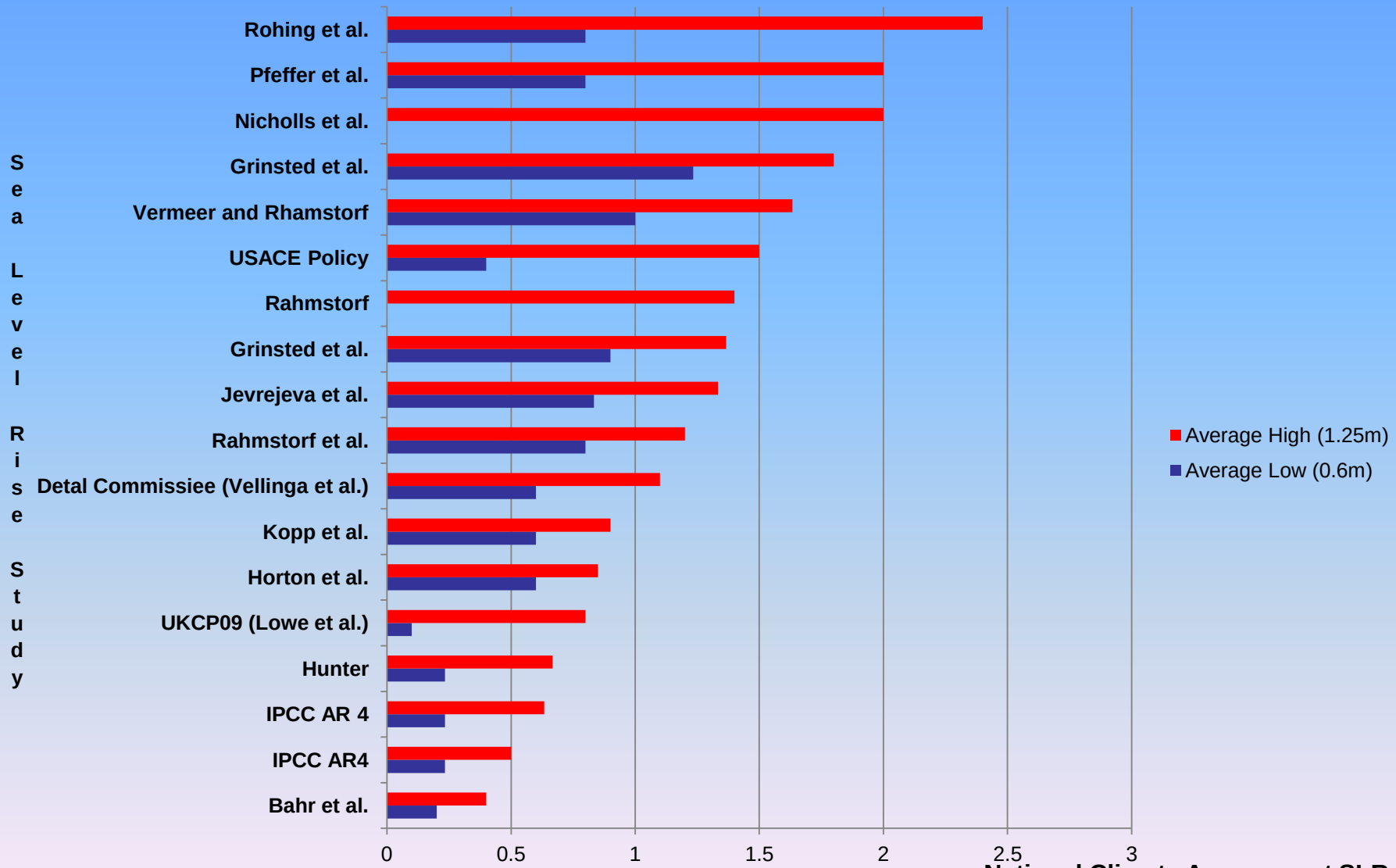
•20th century (tide gauges) = 2 mm/yr (e.g., Church et al., *JOC* 2004)
•1993-present (satellite altimetry) = 3 mm/yr (e.g., Merrifield and Merrifield, *JOC* 2009)

Global Sea Level Projections (by 2100)

- **0.18 to 0.59 m** Intergovernmental Panel on Climate Change (*IPCC*, 2007)
  - does not include ice sheet contributions from Greenland (7 m stored) and Antarctica (60 m + stored)
- **0.5 to 1.9 m** Rahmstorf (*Science*, 2007)/ Vermeer and Rahmstorf (*PNAS*, 2009)
  - relates sea level rise to mean surface temperature
- **0.8 to 2 m** Pfeffer et al. (*Science*, 2008)
  - constrained by observations of ice sheet dynamics
- **5 m** Hansen (*Environ. Res. Lett.*, 2007)
  - non-linearity, amplifying polar feedbacks- 'albedo flip'
  - sea level was 75 m higher at ~50 Ma
  - at 5 Ma, sea level was ~25 m higher , but only 2-3^{o}C warmer (A2 emissions scenario is 4.5 ^{o}C warmer)



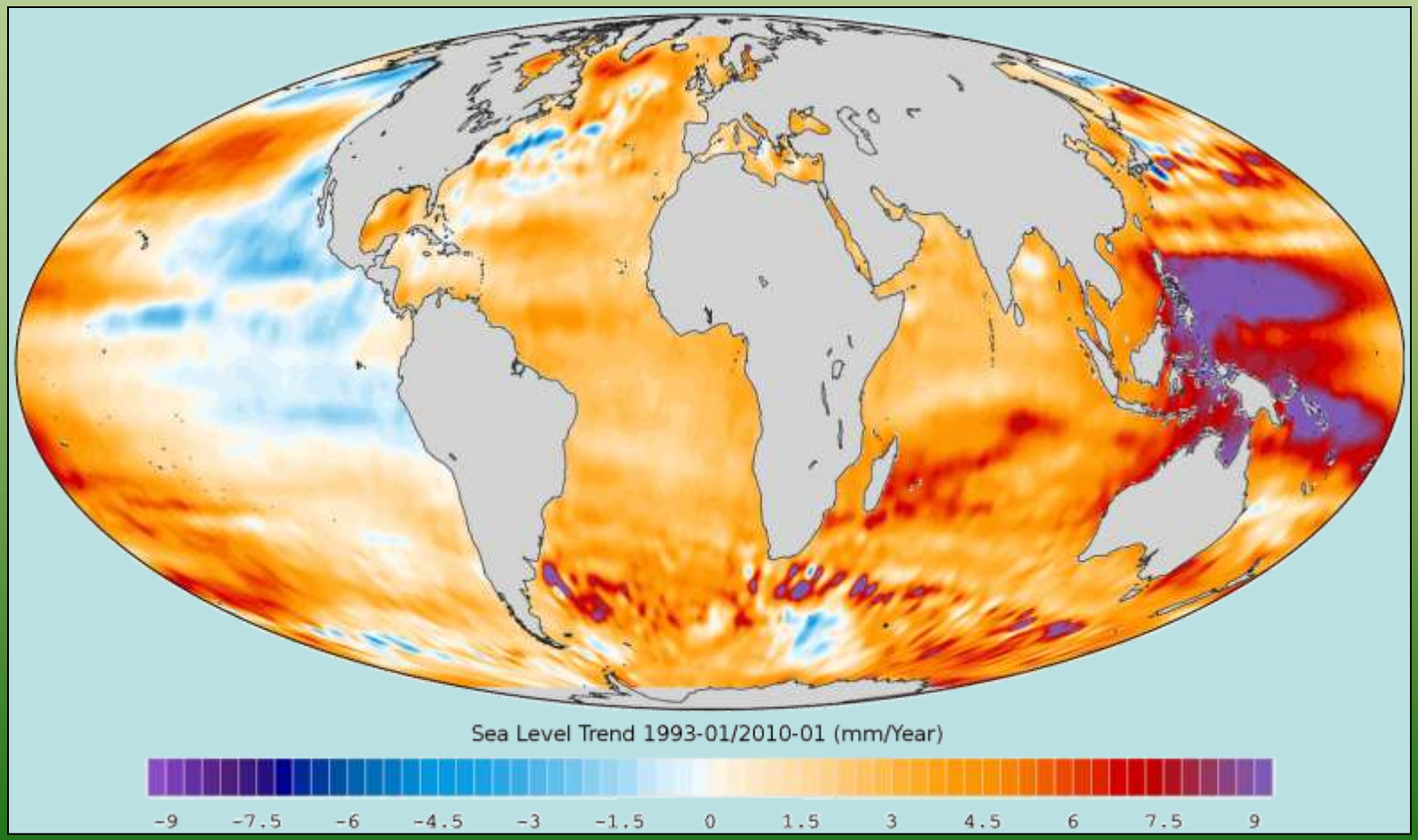
Sea Level Rise Projections
(based on various climate scenarios)



National Climate Assessment SLR Subgroup

Regional Patterns

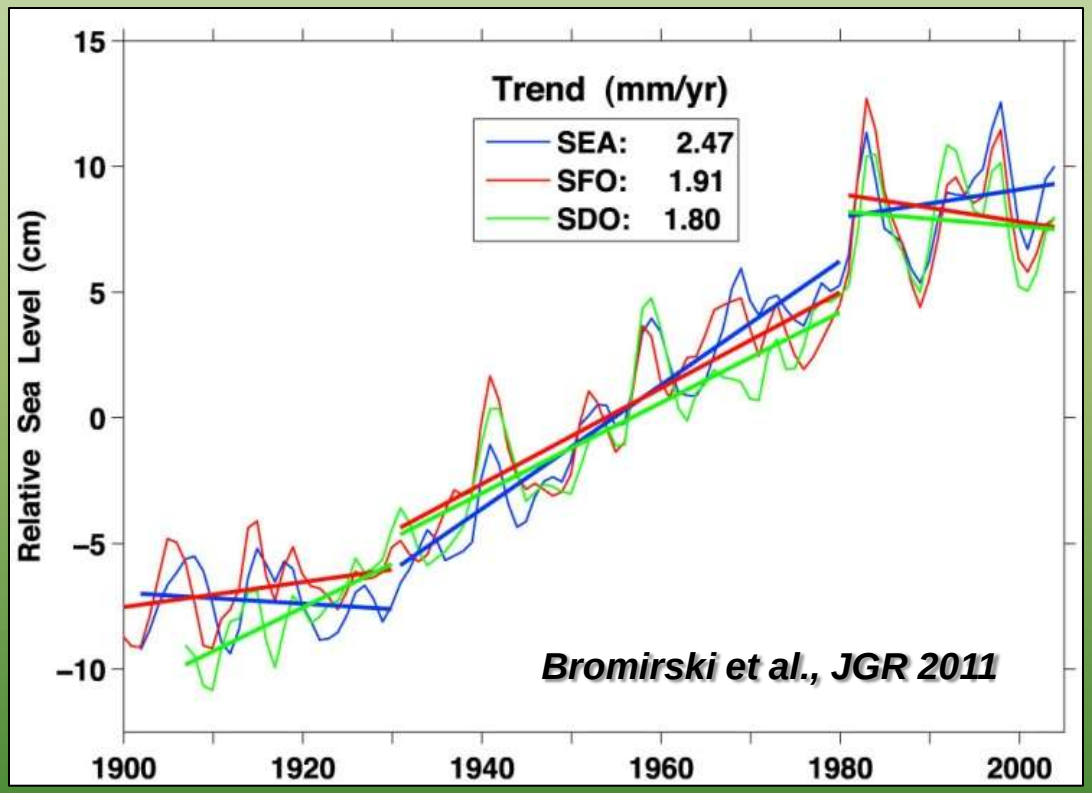
- **Primary factors:**
  - **Ocean circulation patterns**
  - **Isostasy**
  - **Tectonics**



NOAA, 2011

West Coast SLR

West Coast sea level rise has been suppressed for the last thirty years! BUT wind pattern changes may signal return to global or higher rates of SLR (Bromirski et al., JGR 2011).



National Research Council study (due Summer 2012) will provide guidance on West Coast SLR, including isostatic effects, ocean circulation, geodesy, uplift, and storminess.

Local Effects

Land movement:

- **Subsidence due to sediment compaction (natural and fill) and fluid withdrawal (up to order of magnitude higher than Global SLR)**
- **Tectonics (< 0.5 mm/yr on average (Bürgmann et al. 2006)**

Poland and Ireland, 1988

Seasonal and storm impacts (short-term):

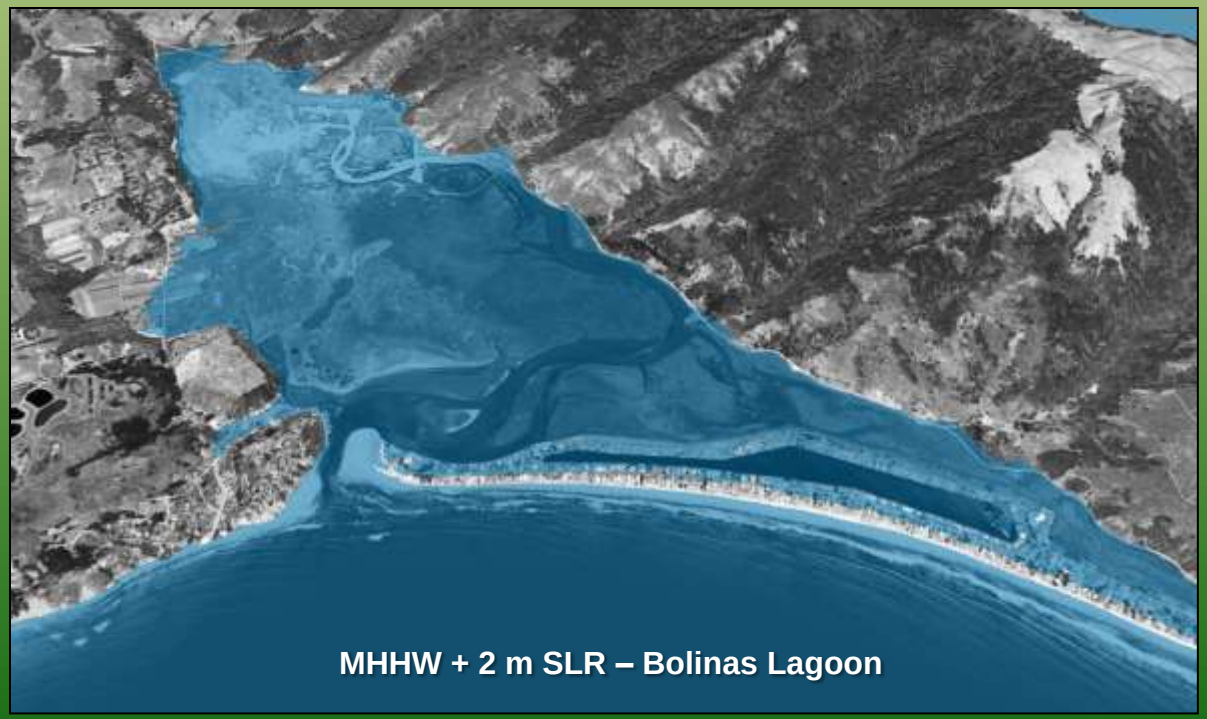
- **Steric effect***
- **Waves and storm surge***
- **River discharge**

***Likely to increase throughout 21st century**


G. Griggs, UCSC

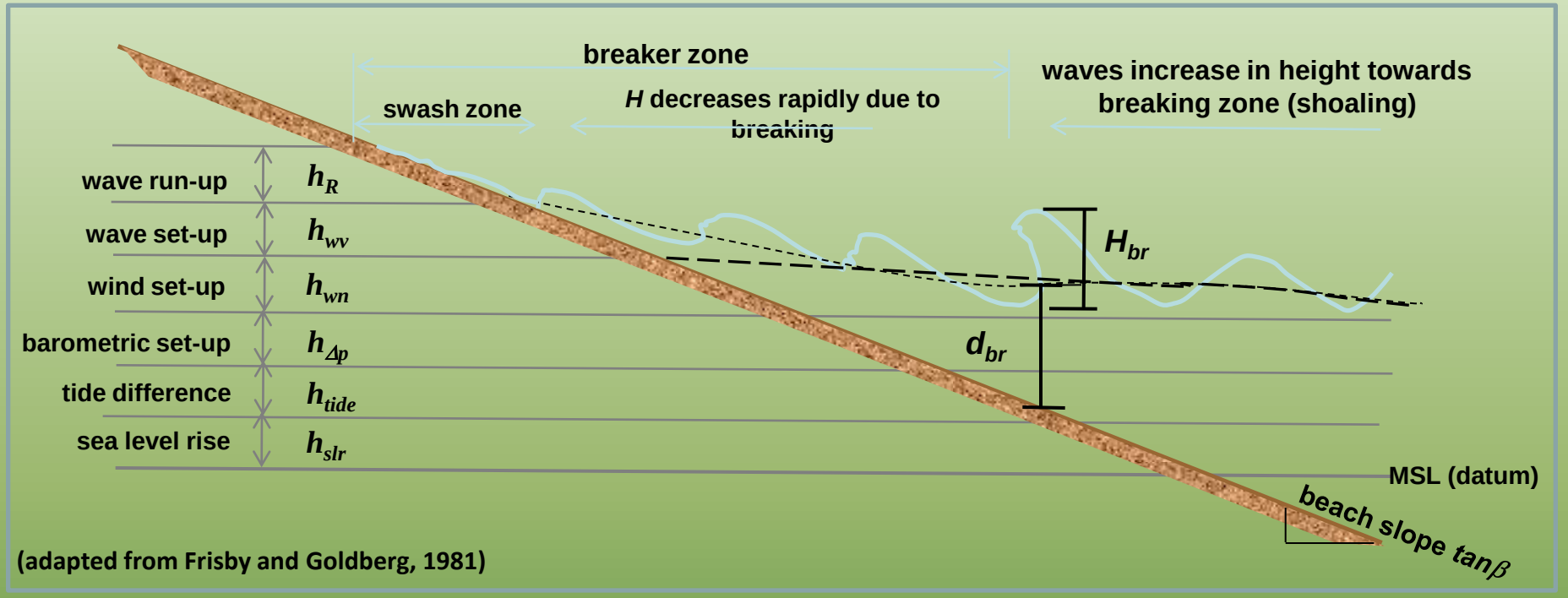
Local Data Needs

- High res topography (lidar) - flood extents
- High res bathymetry (multibeam) - model input
- Periodic lidar or IfSAR - spatial variations in regional land movement (subsidence and uplift)
- Pressure sensors / aerial photography - flood event validation for model improvement
- Fluvial discharge projections



MHHW + 2 m SLR – Bolinas Lagoon

Components of Total Water Level Predictions



SLR Flood Modeling Studies in CA

- NOAA Sea Level Rise Viewer (coming soon)
  - Regional coverage, explicit uncertainty, bathtub model, no hydrodynamics
- USGS CASCaDE (also applied to ART Project)
  - Hydrodynamic model forced by GCM, bathtub model on Bay margin, no wave processes
- USGS CoSMoS (applied in Our Coast-Our Future (OCOF- NOAA, NPS, PRBO))
  - Includes all of the above + flood flow hydrodynamic modeling and wave processes, no relative land motion or fluvial inputs