

FILLING THE NI GAP ON RELATIVE SEA-LEVEL CHANGE FOR UKCIP08: Looking back to see forward

Prof Julian Orford

**School of Geography, Archaeology and Palaeoecology
Queen's University, Belfast**

Prof David Smith

**Environmental Change Unit
Oxford University**

RESEARCH and POLICY ISSUES

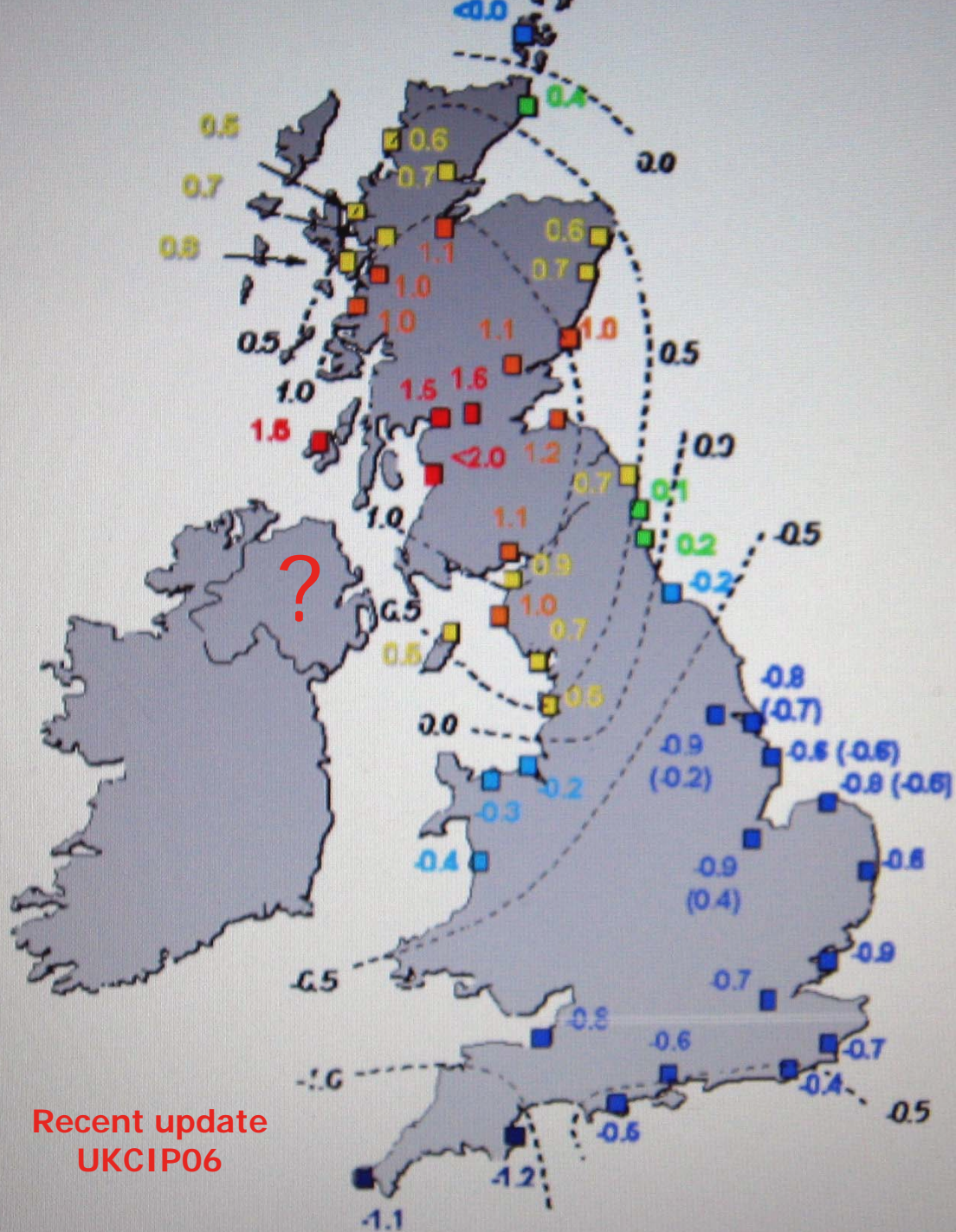
- **Relative sea level change will drive major impacts in 21st century.**
- **RSL is defined by global SL change (eustatic) \pm land changes (isostatic).**
- **RSL is conditioned by crustal change related to deglaciation. There are no current NI estimates of isostatic change.**
- **UKCIP02 is the current statement for regional impacts of climate change in UK. NI missing data. Update in 2008 after IPCC 2007.**
- **Research addresses what can be deduced about past and present crustal responses across northern British Isles, for UKCIP08.**
- **Evaluation of trend for future RSL change.**

ANNUAL CRUSTAL CHANGE

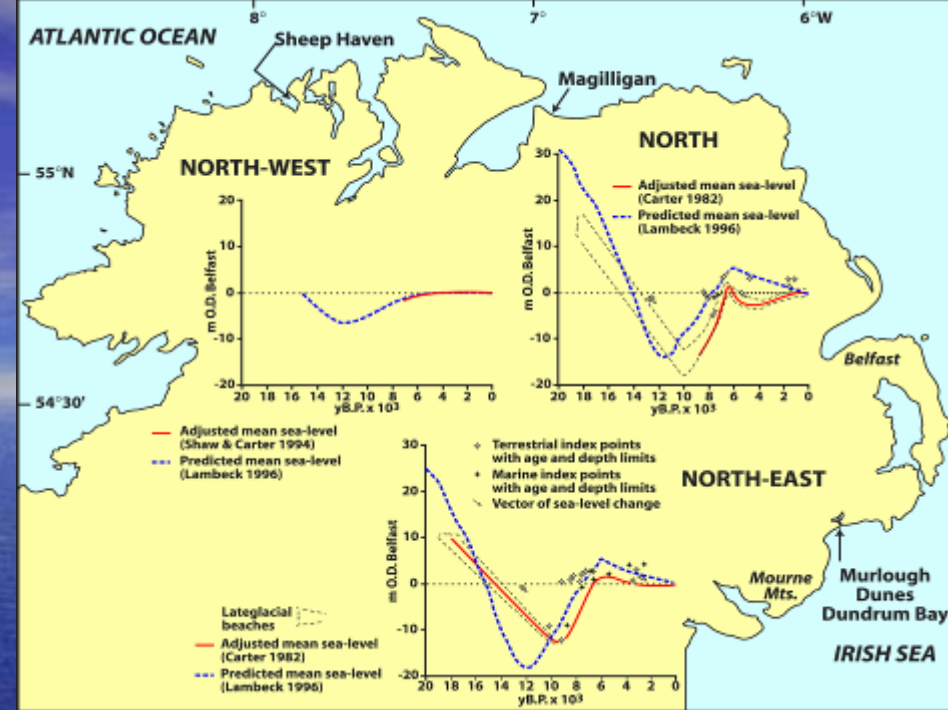
(mm a⁻¹)

Present UK rates of vertical displacement due to isostatic forcing

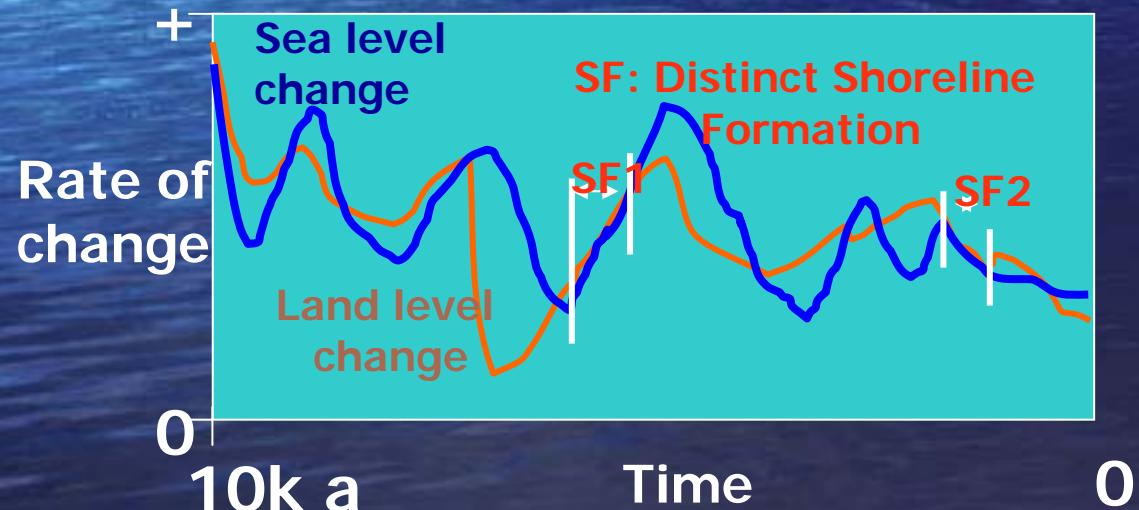
FILLING THE NI UKCIP GAP



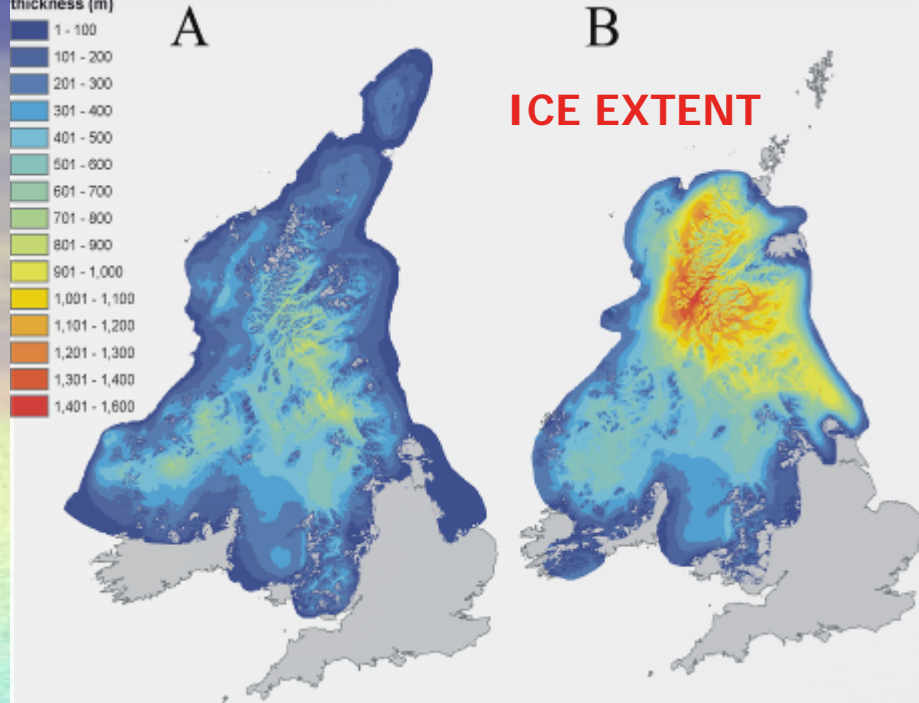
RSLC AROUND THE NORTH OF IRELAND SINCE THE LAST-GLACIATION



FORMATION OF DISTINCT SHORELINES: SCHEMATIC VIEW

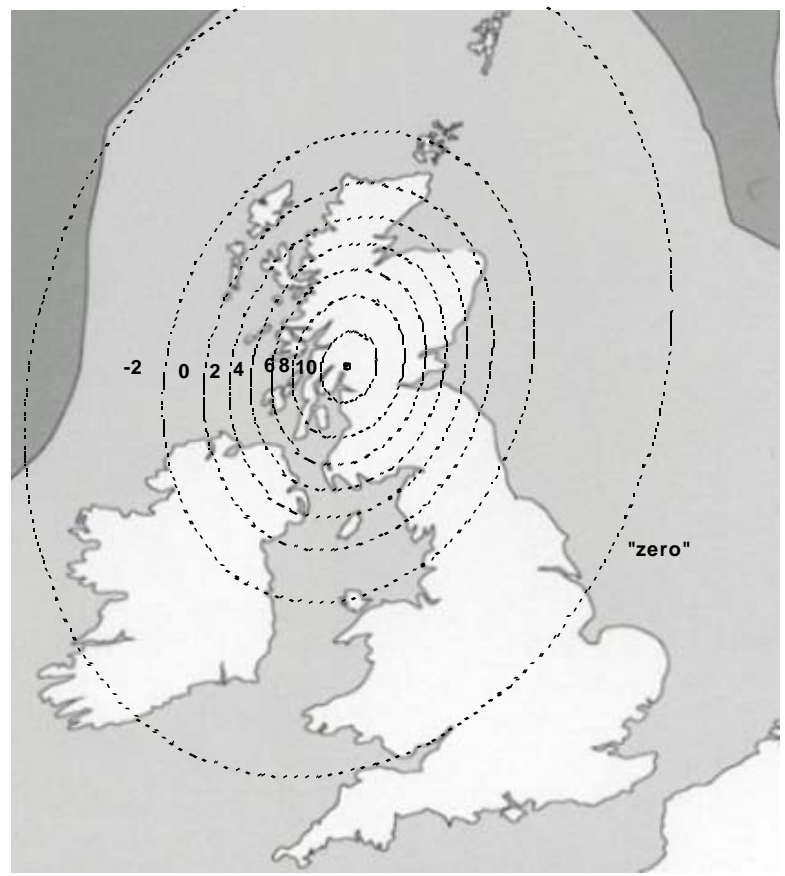


Causeway Coast

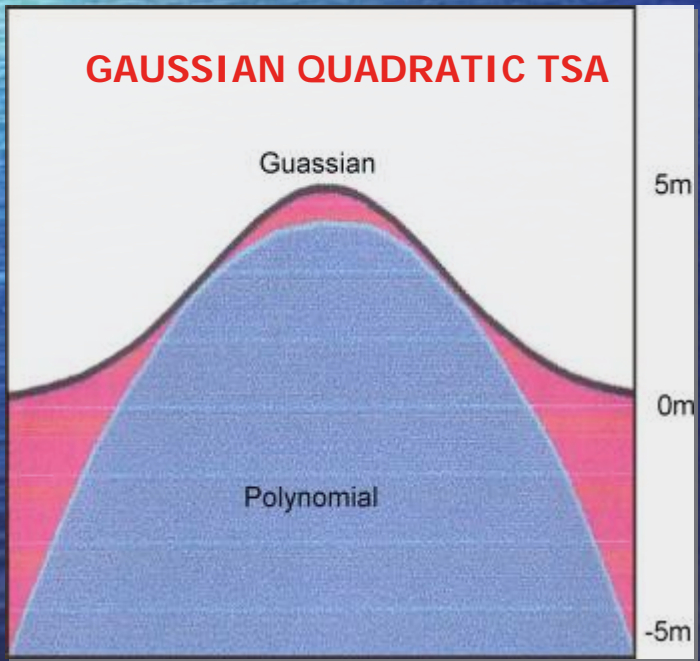


MODELLING ELEVATION CHANGE OF A SPECIFIC SHORELINE

ISOBASES MODEL



GAUSSIAN QUADRATIC TSA

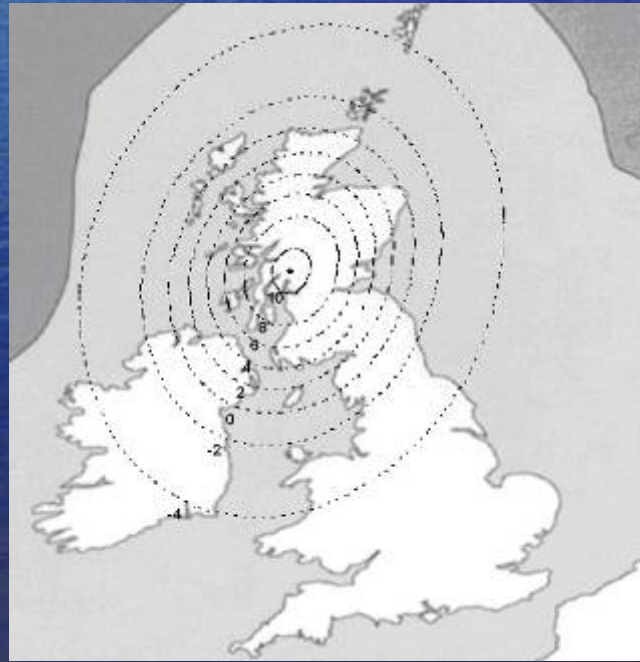


MODELLED ISOBASE DISPLACEMENT FOR RECOGNISED PALAEO-SHORELINES IN SCOTLAND AND IRELAND

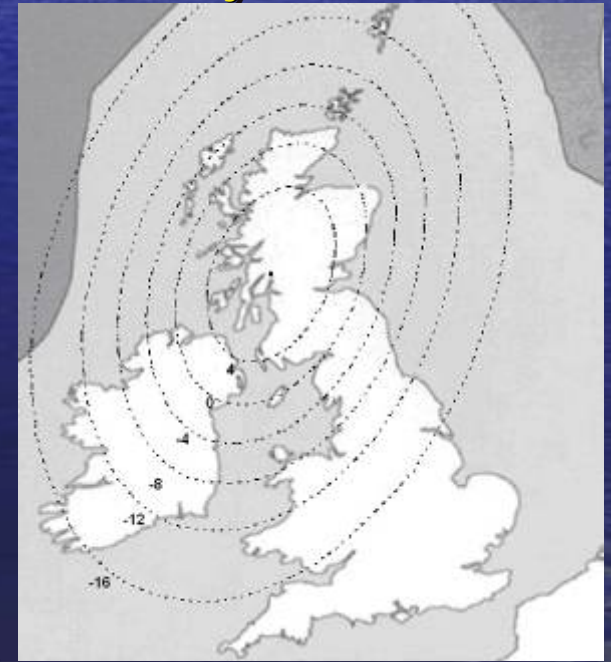
**Blairdrummond
Shoreline: 4,500-
5,800 sidereal years BP**



**Main Postglacial
Shoreline: 6,400-
7,700 sidereal years BP**



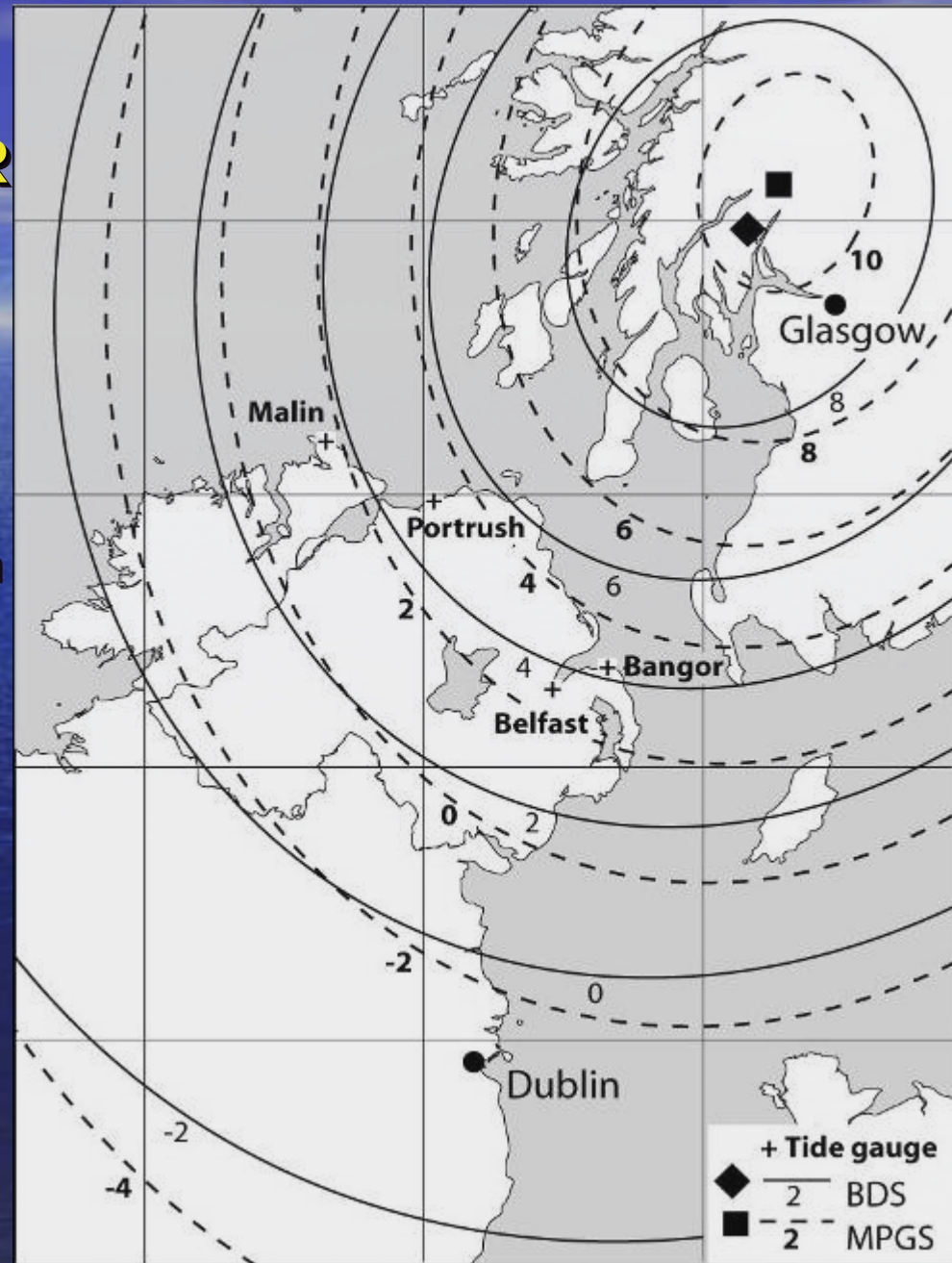
**Holocene Storegga
Slide Tsunami
Shoreline: 7100 carbon
years BP**



TOTAL UPLIFT RATES OVER LAST 7k YEARS

Shoreline isobases for the
Blairdrummond Shoreline (4.5-
5.8k) and Main Postglacial
Shoreline (6.4-7.7k) in Northern
Ireland, superimposed.

1. Contour alignment
2. Similar gradient of shoreline elevation differences across NI



UKCIP08 DATA: NORTHERN IRELAND

| Zone | Mean RSL Change ^a | Isostatic Rate ^b |
|-----------|--|--------------------------------|
| NW Ulster | -0.16 mm a ⁻¹ (±0.17 mm a ⁻¹) ^c | 0.68 - 0.88 mm a ⁻¹ |
| N Ulster | n/a | 1.03 - 1.33 mm a ⁻¹ |
| SE Ulster | -0.2 mm a ⁻¹ (±0.37 mm a ⁻¹) ^d | 0.65 - 0.84 mm a ⁻¹ |

^a Orford, J.D., Murdy, J. and Freel, R. 2006 Developing constraints on the relative sea-level curve for the north-east of Ireland from the mid-Holocene to the present day. Phil Trans Roy Soc A. 364: 857-866.

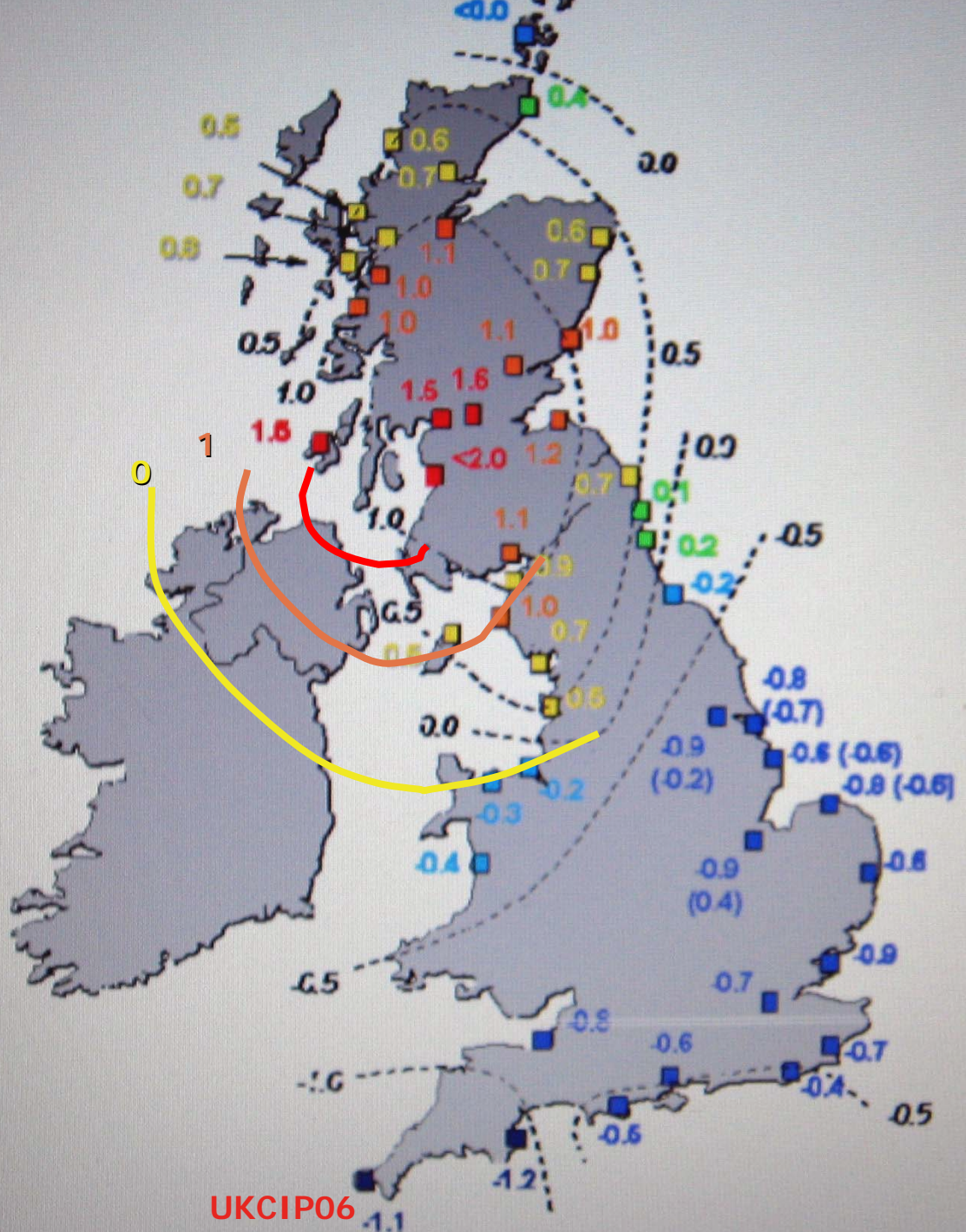
^b Orford, J.D., Smith, D., Harman, M. & Murdy, J. 2007 Recent Sea-level Change around the north of Ireland. Unpub Report for Environment & Heritage Service (NI), Quercus Project QU06-11, 103pp

^c Malin Head tide gauge

^d Belfast Harbour tide gauge

**PRESENT UK
HOLOCENE
RATES OF
VERTICAL
DISPLACEMENT
DUE TO
ISOSTATIC
FORCING**

**Filling the NI
UKCIP gap**



TEST OF ISOSTATIC ESTIMATES

1. Obtain model of 20th century mean RSL change (mm a⁻¹) from British Isles tidal stations for NI based on isobases

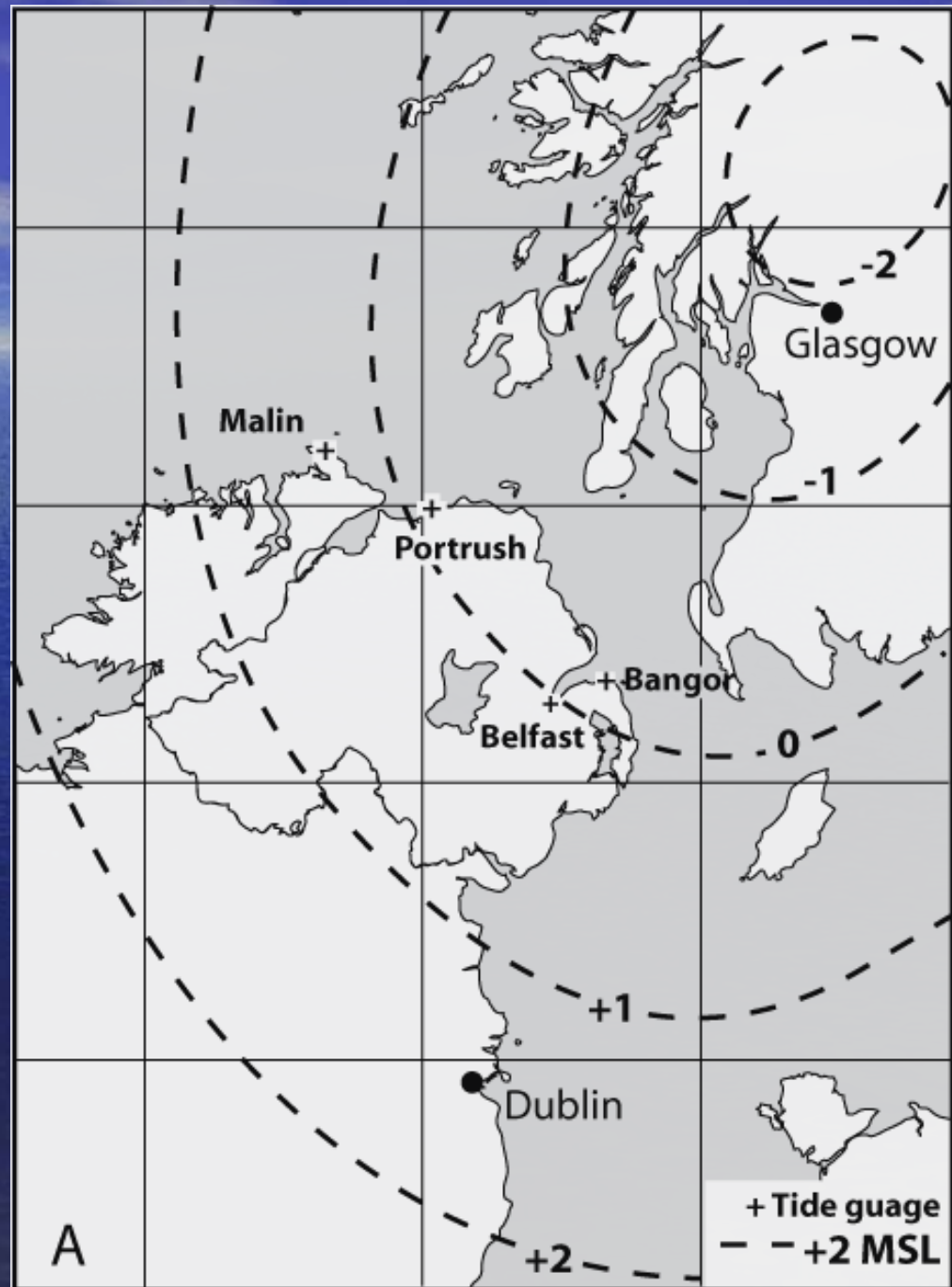
structure

MSL change rate =
 $a + b(\text{distance from ice centre})$



**CONTEMPORARY
RATES OF RELATIVE
MEAN SEA LEVEL
CHANGE FOR THE
NORTH OF IRELAND
(mm a⁻¹)**

**Based on long term UK tide
gauge records and plotted in
terms of the isobase pattern
for the Blairdrummond
shoreline**



Predicted rates of recent relative sea level change rate for locations in Northern Ireland

Based on linear regression of the distance from the isobases centre against 20th century MSL change for the five longest BI tide gauges (including Belfast)

| LOCATION | RATE mm a ⁻¹ |
|-------------|-------------------------|
| Ballycastle | -0.47 |
| Londonderry | +0.41 |
| Portaferry | +0.29 |
| Newcastle | +0.54 |
| Warrenpoint | +1.17 |

2. Check rates of LAND RISE derived from recent assessments of global eustatic SL minus the isobases estimates of relative mean sea level rise around NI

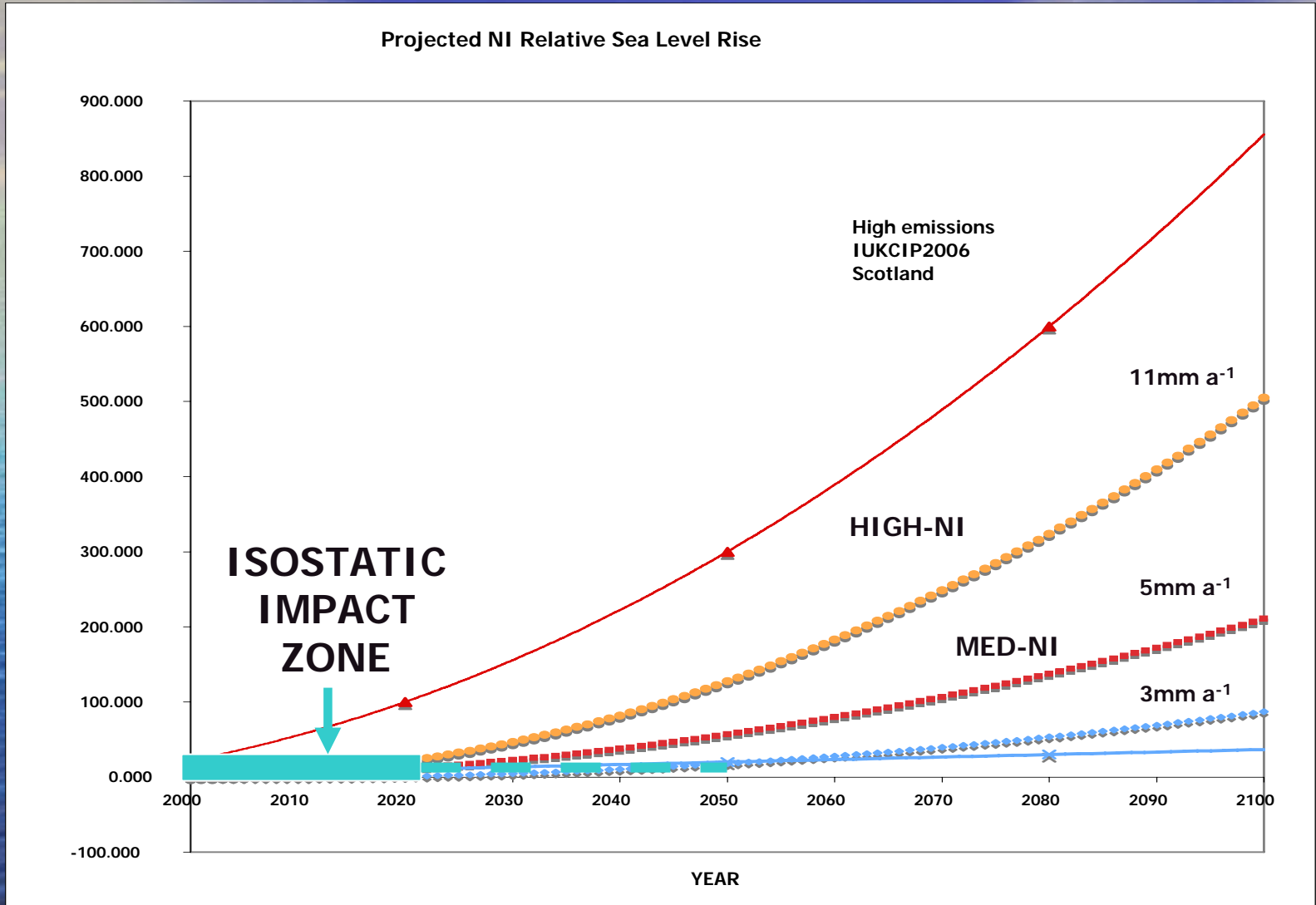
| | IPCC 2001 20th century | Woodworth 2006 Last decade |
|-------------|---|---|
| Location | Land rise for sea-level rise of $1.8 \pm 0.5 \text{ mm a}^{-1}$ | Land rise for sea-level rise of $3.1 \pm 0.7 \text{ mm a}^{-1}$ |
| Ballycastle | 2.27 ± 0.5 | 3.57 ± 0.7 |
| Londonderry | 1.39 ± 0.5 | 2.69 ± 0.7 |
| Portaferry | 1.51 ± 0.5 | 2.81 ± 0.7 |
| Newcastle | 1.26 ± 0.5 | 2.56 ± 0.7 |
| Warrenpoint | 0.63 ± 0.5 | 1.93 ± 0.7 |

Difference from isobases estimate

1-2x

2-4x

FUTURE RSL CHANGE



Future Coastal Scenarios in Northern Ireland (Orford et al, 2007)

CONCLUSIONS

- Estimates of isostatic recovery for NI are now available.
- Estimates show a fan shaped surface centred on northeast NI with values diminishing south and west.
- Estimates suggest that isostatic response is $<2\text{mm a}^{-1}$ for north NI and $<1\text{mm a}^{-1}$ for southeast and northwest NI.
- RSL change shows that estimates are important for next 20-40 years dependent on rate of RSL change, then RSL will probably exceeded these annual levels throughout NI.